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PART
IX.

THE
HEAVENS
FIRE
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EARTH
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LIFE

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POPULAR CYCLOPÆDIA OF NATURAL SCIENCE.

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THE

POPULAR CYCLOPÆDIA OF NATURAL SCIENCE.

BY W. B. CARPENTER, M.D.,

AUTHOR OF "PRINCIPLES OF GENERAL AND COMPARATIVE PHYSIOLOGY," AND
"PRINCIPLES OF HUMAN PHYSIOLOGY."

THE omission of the study of Natural Science from the course of instruction generally followed in this country, appears a neglect of one of the most important means of intellectual discipline and moral improvement which the Almighty has placed within our reach. This study, rightly pursued, has for its object to enable us to read with understanding in that bright volume of Creation, the pages of which are daily and hourly unrolled before us. To every one do "the Heavens declare the glory of God," whilst "the Earth" shows itself "full of His goodness;" but most of all to him who has learned to interpret the wonders they display; and to trace, in the glorious works by which he is surrounded, His power, wisdom, and love.

As a means of intellectual discipline, the study of Natural Science is perhaps second to none. Habits of accurate, discriminating, unprejudiced observation; of cautious reasoning, and of sound judgment; together with a fearless love of Truth, are cultivated by it. Moreover, it has the advantage of interesting the pupil much more than the greater part of the ordinary routine of instruction; and will tend to increase his desire for the attainment of valuable knowledge of any description. Further, at the present day, when Science is constantly furnishing some new and important improvement in those Arts which minister so much to our comfort, and in their turn contribute in various modes to the expansion of the intellect, the practical benefit of a general acquaintance with its principles is sufficiently evident. And whatever portion may be destitute of such direct application, will be found to have uses of its own, in furnishing subjects for the healthy occupation of the thoughts, and objects of pursuit as rational and interesting relaxation.

No works at present before the public appear to be altogether suitable to this purpose; the greater number of *strictly Elementary* Treatises on Natural Science being little else than abridgments of larger works; so that they are much behind the present state of science, and are for the most part but inaccurate copies of one another, executed in a mechanical spirit, and destitute of the striking novelties which scientific research is constantly bringing into view. The Publishers have therefore determined upon bringing out a connected series of Treatises upon the principal departments of Natural Science, designed and executed in accordance with the views above expressed. It is intended that these should all be *founded* upon such knowledge as every person of ordinary capacity possesses, and that the attention of the reader should be directed in the first instance to phenomena of constant occurrence around him; and it is hoped that by a judicious mode of treating the subject, principles may be gradually developed in such a manner as to render them fully comprehensible, and their more extended application thus marked out. "The neglecting to form a proper connection with previously-acquired knowledge; the undervaluing the results of

POPULAR CYCLOPÆDIA OF NATURAL SCIENCE.

ZOOLOGY.

PART III.

CONTAINING FISHES, INSECTS, ARACHNIDA, AND CRUSTACEA.

BY

WILLIAM B. CARPENTER, M.D., F.R.S.,

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HISTORY AND COMPARATIVE ANATOMY AT ST. THOMAS'S HOSPITAL.

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CHAPTER VI.

OF THE CLASS OF FISHES.

515. THE fourth and last class of the Vertebrated sub-kingdom, comprises the animals known as FISHES. These are destined to live altogether in the water; and this circumstance has impressed a peculiar character on their entire organization: but the most important differences which they present, when we compare them with the other Vertebrata, consist in the conformation of their apparatus for respiration and circulation. They have no lungs at any period of their lives; and they breathe by gills only. Their heart contains but two cavities; and receives only venous blood. This liquid, after having been brought into contact with oxygen, passes into a dorsal vessel, where no new force accelerates its course through the different parts of the body. Their circulation cannot, therefore, be as active as among the higher animals; and their blood is cold like that of Reptiles. Their skin is covered only with scales, which, in some instances, are scarcely discoverable, so that the skin appears quite bare; they have no mammary glands like the Mammalia, and they are reproduced by means of eggs; lastly, their members have the form of fins.

516. The external form of Fishes varies; but their body is generally but little divided. Their head, which is as broad as the trunk, is not separated from it by any narrowing like the neck of the higher Vertebrata; and their tail, by its size at its origin, is not distinguished from the rest of the body. Some of these animals are quite destitute of fins; but in general we find a considerable number of these organs, placed,—some on the central line of the back or the abdomen, and consequently single, —others on the sides, and arranged in pairs (Fig. 245). These last represent the four limbs of the other Vertebrated animals.

The anterior members, which correspond with the arms of Man and the wings of Birds, are fixed on each side of the trunk, immediately behind the head, and are called *pectoral fins*. The abdominal members are less separated from each other, and are generally found on the lower side of the body; they may be situated more or less forwards or backwards, from the under part of the throat to the commencement of the tail; these are called *ventral fins*. The single fins occupy, as we have already said, the central line of the body; and are divided into *dorsal fins*, *anal fins*, and *caudal fins*, according as they are placed along the back, under the tail, or at its extremity. They have all very nearly the same structure, and consist almost always of a fold of skin, supported by bony or cartilaginous rays; very nearly in the same manner as the wings of bats and dragons are sustained by the fingers or by the ribs, of the animals.

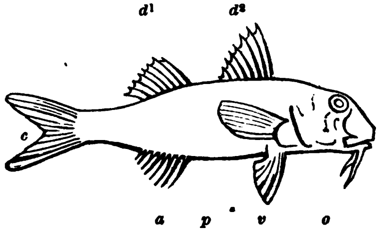


FIG. 245.—BEARDED MULLET, showing position of fins; *p*, pectoral fin; *v*, ventral fin; d^1, first dorsal; d^2, second dorsal; *c*, caudal; *a*, anal; *o*, opening of gill-covers.

517. On the external surface of the body, large openings are seen on each side; which are placed immediately behind the head, and which serve as an outlet for the water that has passed through the gills. In general there is only one on each side; and its anterior edge is moveable, and resembles a flap or valve. There exists on each side, along the whole length of the body, a series of pores, which is termed the *lateral line;* these are the openings of glands imbedded in the skin, by which the thick mucus is secreted, that covers the skin of Fishes, and gives to it its peculiar slipperiness.

518. The skin is sometimes almost entirely bare, but it is generally covered with scales. Occasionally these scales have the appearance of coarse grains, at other times they exist as large tubercles or plates of a considerable thickness; but in general

they present the aspect of very thin laminæ or plates, arranged in the manner of tiles upon a roof, and held together in the folds of the skin. We may compare them to our nails; but they contain a much larger quantity of calcareous salts. The colours with which these animals are adorned, astonish us by their variety and splendour. Sometimes they can only be compared to the most brilliant gold and silver; sometimes these present tints of the richest green, blue, red, or the deepest black. The silvery matter, which frequently gives to them so beautiful a metallic splendour, is secreted by the skin, and is composed of a number of small polished laminæ.

519. The Skeleton of Fishes is usually bony; but amongst several of these animals, such as the Ray and the Shark, it remains permanently in a fibro-cartilaginous or cartilaginous state; and there are even some in which this frame-work possesses still less solidity, and remains perfectly membranous: certain Lampreys are in this condition; and in this manner they form a transition between the Vertebrated and Invertebrated animals.—The bones never have any medullary canal; and the cartilage which constitutes their foundation is not the same as that of the Mammalia and Birds; for, when boiled in water, it does not give out any gelatine.

520. The skeleton is composed of the head, to which is joined a highly-developed apparatus which is subservient to

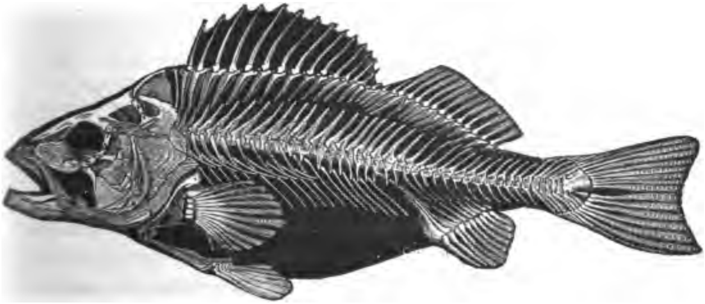


FIG. 246.—SKELETON OF THE PERCH.

respiration; of the trunk; and of the members.—The structure of the head is very complicated. At first is seen a central or median portion, composed of a great number of bones united together by sutures, and forming a kind of immoveable keel, with which are connected the bones of the jaw, the cheeks, &c. This median portion, of which the general form is very nearly that of a pyramid with three sides, having its summit directed forwards, has at its back part the cavity of the cranium; in which is placed the apparatus for hearing, as well as the brain. Its middle side is hollowed out to form the orbital cavities, *or;* and in front are seen the apertures belonging to the olfactory apparatus, *n;* and a kind of large knob, formed by the vomer, and serving to support the upper jaw (Fig. 247.) We may distinguish the bones corresponding with the occipital, the temporal, the sphenoid, the parietal, the frontal, the ethmoid, and the vomer; but most of these are composed of several pieces, which never acquire the union that takes place at an early period among the Mammalia and Birds.—At the anterior extremity of this cranial portion of the head is placed the upper-jaw, which is sometimes fixed there in an immoveable manner, but in general preserves great freedom of motion; there may be distinguished in it on each side an intermaxillary bone, placed near the medial line, and a maxillary bone, which extends sideways, and which is moveable upon the first.

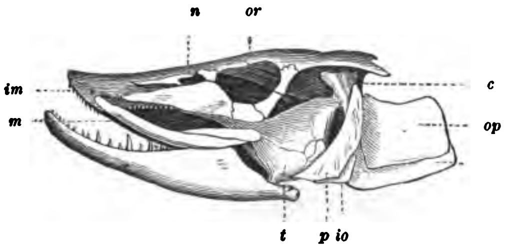


FIG. 247.—Bones of the head of Pike; *c*, cranium; *or*, orbit; *n*, nasal cavities; *im*, intermaxillary bone; *m*, superior maxillary bone; *t*, lateral partition, separating gills from mouth; *p*, *io*, *op*, bones of operculum, or gill-cover.

521. A chain of small bony pieces extends on each side, from

the anterior angle of the orbital cavity to its posterior angle, and thus completes the circle of the orbit. Further inwards is seen also on each side a kind of vertical partition, (Fig. 247 *t*,) which is suspended to the skull, and which separates the orbits and the cheeks from the mouth. It is formed by bones corresponding with the palatine, pteregoid, and tympanic bones of the higher Vertebrata. At its under part it gives attachment to the lower jaw; and behind it is prolonged in such a manner, as to form a kind of moveable flap, which protects the respiratory apparatus, and is termed the operculum or gill-cover. The lower-jaw is formed of three pieces on each side. Within the lateral partitions just described, and lying at the bottom of the mouth, is found a framework of very complicated structure,

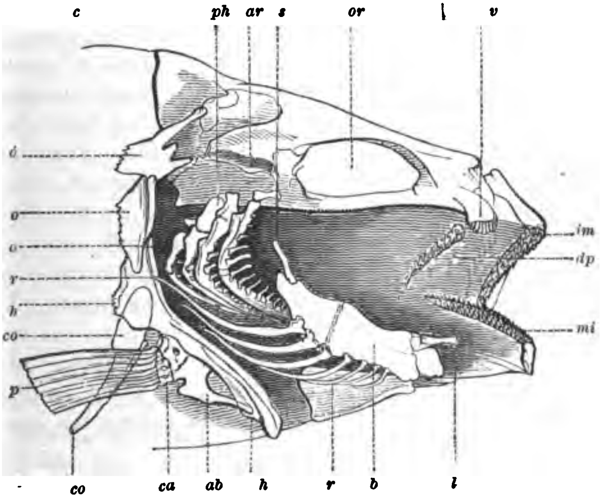


FIG. 248.—Bones of the head of the Perch, after the removal of the jaws, lateral partition, and operculum, on one side, to show the interior of the mouth, and the hyoid apparatus; *c*, cranium; *or*, orbit; *v*, vomer (armed with teeth); *im*, superior maxillary; *dp*, teeth implanted on the palatine arch; *mi*, lower jaw; *l*, lingual bone; *b*, lateral branches of the hyoid apparatus; *s*, process for the attachment of these to the lateral partition; *r*, *r*, branchio-stegal rays; *a*, branchial arches; *ph*, superior pharyngeal bones; *ar*, articular surface by which the lateral partition is attached; *o* to *h*, bony framework supporting the pectoral fin, *p*; *o* and *o'*, scapula divided into two pieces; *h*, humerus; *ab*, bone of the fore-arm; *ca*, bone of the carpus; *co*, coracoid bone.

which serves for the support and protection of the gills, and which appears to resemble the hyoid bone of higher animals enormously developed (Fig. 248.) The bone of the tongue, *l*, is continued backwards by a series of pieces on the central line; and is articulated on each side with a lateral branch of great length and thickness, which, by its opposite extremity, is suspended (as it were) to the internal face of the before-mentioned partition. These lateral branches, formed of several bones, carry at their lower border a series of flattened rays, *r*, *r*, curved backwards, which unite with the opercular bones to complete the walls of the branchial cavities, and which are known under the name of *branchio-stegal* rays. Behind these branches we meet with four pairs of bony arches, *a*, passing off from the central portion of the hyoid apparatus. These are first directed backwards; then they curve upwards and inwards; and at last they are fixed to the base of the cranium by a series of small connecting bones, *ph*, termed the superior pharyngeal. These arches support the gills, and are thence called *branchial arches*. Lastly, behind the last pair of these, at the entrance of the œsophagus, are seen two inferior pharyngeal bones; which are usually so placed, as to apply themselves against the superior pharyngeals just mentioned.

522. Such is generally the complicated structure of the bony head of Fishes. Some anomalies, however, are occasionally observed; thus amongst the Sword-fishes and some other allied species of Tunny, the upper jaw is prolonged, so as to constitute a kind of beak, like a spit or the blade of a sword; which serves these fish as a powerful weapon to attack the largest marine animals. We shall not dwell here on the comparison of the different pieces of which the head of Fishes is composed, with the bones of the head of the Mammalia; as there still exists much uncertainty on this point:

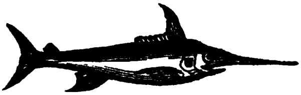


FIG. 249.—SWORD-FISH.

523. The vertebral column, which immediately follows the head, only presents two distinct portions, the one dorsal, the

other caudal (Fig. 246); for here there is neither neck nor sacrum. The body of the vertebræ has a peculiar form, being hollowed before and behind into a conical cavity; these two cavities sometimes unite in such a manner, as to form a continuous passage; and the double conical cavity, which is formed when two vertebræ are placed together, is filled with a soft substance. The ring destined for the passage of the spinal marrow is surmounted by a spinous process; and on each side there is generally seen a transverse process more or less distinct, which, beneath the abdominal cavity, extends outwards, and is usually united with the corresponding rib; but which, in the caudal portion of the column, is directed downwards, and often forms with that of the opposite side a ring, from the lower part of which arises a long and spinous process, similar to that which is situated on the dorsal side of the vertebræ.—The ribs are sometimes entirely absent; at other times they surround the abdomen, and amongst a small number of Fishes they are joined to a series of single bones, which ought to be considered a sternum. They often bear one or two pointed projections, which are directed outwards, and penetrate into the muscles. There are also, sometimes, similar processes, which spring from the bodies of the vertebræ; and it is thus that, in some tribes, such as amongst the Herrings, the small bones of Fishes become very numerous. Lastly, we find on the central line of the body a number of bones, termed *interspinous* (Fig. 250), which are usually applied against the extremities of the spinous processes of the vertebræ, and which articulate at their opposite ends with the rays of the median fins. These rays are sometimes pointed bones, which are then termed *spines*: but they are sometimes ossified only at their bases, the remainder being formed of a series of little cartilaginous pieces, jointed together; and often branch-

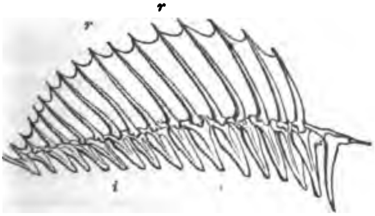


FIG. 250.—DORSAL FIN, supported on spiny rays, *r*, *r*, and these resting on interspinous bones, *i*. *i*.

ing at their summit; these are termed *articulated* or *soft rays;* the caudal fin is entirely formed of them (Fig. 246); and sometimes there are no others.

524. The lateral fins, which represent the members, are terminated by rays similar to those of the vertical fins, and analogous to the fingers. In the pectoral fin are seen, at the base of these appendages, a transverse series of four or five small bones (*c a*, Fig. 248), which are analogous to those of the carpus; and these, in their turns, are fixed to two flat bones, *a b*, which seem to be the radius and ulna widened. This apparatus is supported by a kind of bony girdle situated immediately behind the ears, on which the operculum or gill-cover is fixed; and it consists of three bones, extending from the cranium to the hyoid apparatus, and prolonged backwards into a pointed process. The principal piece which enters into its composition, is that which bears the fore-arm, and which may consequently be regarded as the humerus, *h;* it is united below with that of the opposite side and with the central prolongation of the hyoid apparatus; and it is connected with the cranium by two bones (*o*, *o*), which are regarded by Cuvier as analogous to the scapula; and lastly, the pointed process which is prolonged over the sides of the body, is ordinarily formed of two pieces, and may be compared to the coracoid bone, *co.*—The posterior member is less complicated; the rays of the ventral fin are only supported on a single bone, usually of triangular form, which is frequently attached to the central portion of the osseous girdle of the anterior member, and which, in other instances, is merely suspended by the muscles, having no bony connexion with the skeleton of the trunk.

525. In *Cartilaginous* fishes, such as the Rays and the Sharks (of which the Dog-fish is a common species), the arrangement of the skeleton differs from that which we have already described, and exhibits a great resemblance to that of the still cartilaginous skeleton of the Tadpole. The skull is not divided by sutures, and is only composed of a single piece; this, however, is formed in other respects very nearly like the skull of ordinary Fishes. The upper jaw is formed by pieces analogous to the palatine bones and the vomer; the maxillary and the intermaxillary do

not exist, and are only found in a rudimentary state, hidden under the skin. The lower jaw has in like manner only one piece on each side, and the opercular apparatus is generally altogether wanting. The vertebral column is sometimes chiefly formed of a single tube, pierced on each side for the passage of the nerves, but not divided into distinct vertebræ. The bodies of the vertebræ are also frequently pierced through, so that the gelatinous substance which fills up the intervals of these bones forms a continued line through the whole column. The arrangement of the bones of the shoulder, of the pelvis, and of the fins, varies. Lastly, the hyoidean apparatus which supports the gills is usually formed very nearly in the same manner as amongst ordinary fish; but in the lowest groups of this class (amongst the Lampreys for example) the branchial arches are absent.

526. The greater number of Fishes swim with great agility; we are told that the Salmon, for example, advances sometimes with a rapidity of twenty-six feet in a second, and travels in one hour the space of from twenty to twenty-five miles. In general, it is through lateral strokes on the water, by the alternate bendings of the tail and the body, that they can move in this manner; and the muscles which are destined to bend the vertebral column laterally, are so developed, that they usually constitute the greatest part of the mass of the body. The fins on the central line, that is to say, the caudal, the dorsal, and the anal, serve to increase the extent of this kind of oar: but the lateral fins—the pectoral and the ventral—act but little in *progression*, or forward movement; and their principal use is generally to influence the *direction* of the course, and especially to support the animal in equilibrium.

527. A peculiarity in the organisation of Fishes, which is a great assistance to them in swimming, is the existence of a kind of bag filled with air, and constructed in such a manner as to be capable of being compressed at will. This *swimming bladder* is situated in the abdomen, and under the dorsal spine; and it usually communicates with the œsophagus, or with the stomach, by a canal, through which the air contained in its interior can escape; but this fluid does not appear to penetrate into it by

this passage, for it rather seems to be the product of a secretion, having its seat in a glandular portion of the walls of the reservoir itself; and sometimes this is completely closed. By the movements of the ribs, this elastic vessel is more or less compressed; and, according to the space that it occupies, it gives to the body of the fish a specific gravity, equal, superior, or inferior, to that of the water; and thus enables it to remain in equilibrium, to descend, or to rise, in this liquid. It has been remarked that it is often absent, and that it is generally very small, in the species destined to swim at the bottom of the water, or even to bury themselves in the mud, such as the Rays, Soles, Turbots, and Eels.

528. Amongst a small number of Fishes, the pectoral fins have an extreme development, and thus permit the animal to support itself for some minutes in the air after it has leaped out of the water. The Dactylopterus affords an example of this construction. There are some, which, by crawling, or by repeated leaps, can advance upon the ground. Some have been mentioned which can climb trees; but these examples are very rare.

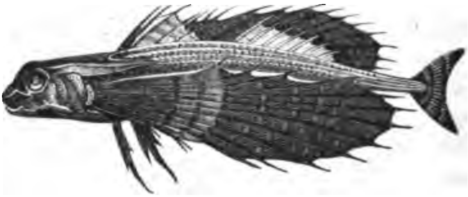


FIG. 251.—DACTYLOPTERUS, ONE OF THE FLYING FISH.

529. In treating of the organs for movement amongst Fishes, we must not omit to mention a very singular apparatus, which is seen in some of these animals, and which enables them to adhere with great firmness to foreign bodies. This is a flattened disc, which covers the upper part of the head, and which is composed of a certain number of cartilaginous and moveable plates, directed obliquely backwards (Fig. 252). The Fish of the genus *Echineis* are the only species which present this mode of organisation; and one of them, which lives in the Mediterranean and in the Atlantic, and which has been for a long time

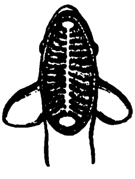


FIG. 252.—SUCKING-DISC OF THE REMORA.

celebrated under the name of *Remora*, or Sucking-Fish, (Fig. 253) has been the subject of many amusing and absurd fables. It has been pretended that this small fish supports itself by a kind of suction through the disc just described; and the power of stopping a large vessel in rapid progress has been attributed to it. A species allied to the preceding is very common in the waters of the Isle of France; and it appears that, upon the coasts of Caffraria, it is employed in fishing, by allowing it to pursue fish, and then drawing it back, by means of a line attached to its tail, as soon as it has fastened itself upon its prey.

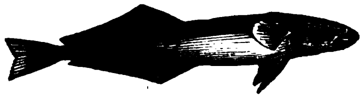


Fig. 253—Remora.

530. The life of a Fish is passed almost entirely in seeking its subsistence, and in flying from its enemies. Its external senses only appear to give it a few obtuse impressions; and its faculties are more or less limited. It shows no industry, nor any remarkable instinct; its brain is very slightly developed, and its organs of sense are very imperfect. The cavity of the skull is small compared to the size of the body; and the brain does not nearly occupy it. Between its sides and the brain is found a spongy and fatty mass of a considerable size, particularly in adult individuals. The lobes which compose the brain are placed in a row, one behind the other; in front we see the olfactive ganglia, *ol*, often separated from the rest by a peduncle or foot-stalk; next the cerebral hemispheres, *ch*; then the optic lobes, *op*, which are often larger than the preceding; then the cerebellum, *ce*; and, behind all these parts, the lobes belonging to the medulla oblongata, *sp*.

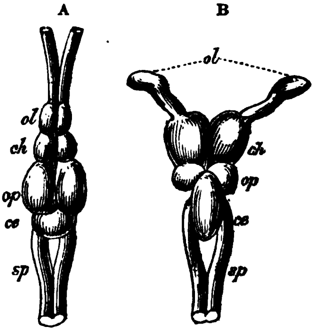


Fig. 254.—Brains of Fishes. A, Cod; B, Shark.

531. The nature of the integuments of Fish necessarily renders their sense of feeling very imperfect; and deprived as they are of prolonged members, and particularly of flexible fingers adapted to take hold of objects, it is only by means of their lips that they can exercise the sense of touch. The filaments which are often seen around the mouth, appear to inform them of the contact of bodies. The sense of taste must also be very nearly absent; for their tongue is scarcely moveable, and is not fleshy; it receives very few nerves, and the food never remains long in the mouth. The apparatus for smelling is of a much more complicated structure; but is not arranged so as to allow either air, or the water serving for respiration, to pass through it. The nasal fossa only consists of two cavities, closed at the back; each generally opens outwards by two nostrils, and is furnished by a pituitary membrane folded in a very remarkable manner. The ear is nearly always placed completely within the cavity of the skull, upon the sides of the brain; and simply consists of a vestibule surmounted by three semicircular canals, at which the sonorous undulations can only arrive after having put into vibration the common integuments and the bones of the cranium. In general we see nothing that can be compared to the external ear, to the membrana tympani, or to the drum. Lastly, the eyes are very large and nearly immoveable; they have no true eyelids, nor lachrymal apparatus. The skin is continued over the eye, and is thin enough to be traversed by the light. The cornea is almost flat; the pupil very large, and but little or not at all contractile; and the crystalline lens is spherical. These organs generally do not usually present any peculiarity as to their position; but amongst some fish there is a remarkable anomaly. Thus, amongst the Soles, Plaices, Turbots, and other flat-fish, they are not placed as usual on both sides of the head, but are both situated on the same side; and this kind of mon-

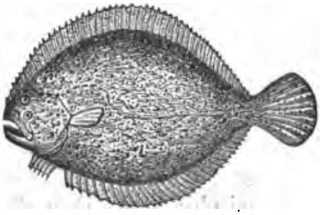


FIG. 255.—TURBOT.

strosity coincides with a defect of symmetry in other parts of the body.

532. Fishes are very voracious; there are only a few which live principally on vegetable matter; and generally they swallow without any selection all the small animals which come within their reach. Some species are destitute of teeth, but amongst the greatest part, they exist in several rows, as in the mouth of the Shark, for example; and they are more commonly found, not only in the two jaws, but also on the palate, implanted on the vomer and palatine bones,—on the tongue,—upon the interior edge of the branchial arches,—and even in the back of the mouth upon the pharyngeal bones, which surround the entrance of the œsophagus. They have never any roots, but are fixed to the bones which support them; they fall off nevertheless—probably by a mechanism analogous to that of the fall of the horns of the stag—and are replaced by new teeth, which arise sometimes beneath, sometimes by the side of the old ones. The teeth with which the jaws are armed, only serve, in general, to hold or to crush the prey; those situated at the bottom of the mouth are rarely (in existing fishes at least) disposed in such a manner as to reduce it. Their form varies very much; sometimes they are so fine and closely set, that they present the appearance of velvet; whilst in other instances they constitute strong hooks, plates with cutting edges, or rounded tubercles.

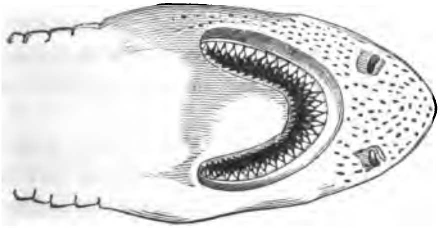


FIG. 256.—HEAD OF SHARK.

533. There are some Fish which are not supported on solid matter, and which live only by sucking the liquids which they draw from the bodies of other animals; the Lampreys are an example of this. Their mouth, instead of having the usual arrangement, presents a very singular structure, but one which is in complete accordance with its functions. The cartilages,

which amongst the Rays, &c. form the jaws, are here united into rings, and support a fleshy disc, the surface of which is furnished with teeth, whilst its centre is occupied by the mouth. The tongue also is supplied with teeth, and moves forwards and backwards like a piston; so that the animal can make use of this apparatus, either to fix itself upon another body, or to pump up the fluids on which it is supported.

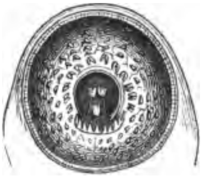


FIG. 257.—MOUTH OF THE LAMPREY.

534. The mouth is not surrounded by any salivary gland. The œsophagus is short; the stomach and the intestines vary in size and form. The liver is generally large, and of a soft tissue; the pancreas is nearly always replaced by peculiar cœcal appendages placed around the pylorus; the position of the anus varies much; sometimes it is found under the throat, at other times under the tail. The kidneys are extremely large, and extend themselves on both sides of the vertebral column, through the whole length of the abdomen. Their excretory passages end in a kind of bladder, whose external opening is placed immediately behind the anus and the orifice of the reproductive organs. The digestive process appears to be performed very rapidly; and the chyle is absorbed by numerous lymphatic vessels, which empty themselves by several trunks into the venous system near the heart.

535. The blood of Fishes, as already mentioned, is red; and the globules have an elliptical form, and are of considerable dimensions. The heart is placed under the throat, in a cavity divided from the abdomen by a kind of diaphragm, and protected by the pharyngeal bones above, by the branchial arches on the sides, and in general by the humeral girdle behind. It is composed of one auricle, which receives the venous blood collected into a large sinus situated in its neighbourhood; and of a ventricle placed beneath it, and giving rise at its anterior extremity to a pulmonary artery, which is swollen out at its origin into a contractile bulb. This vessel soon divides into lateral branches, which are distributed to the gills; and the blood, after having

traversed these organs, passes towards the head by another vessel, which in like manner runs along the edges of the branchial arches. These canals then send out some branches to the neighbouring parts, and are united together again to form a large dorsal artery, which passes backwards, beneath the vertebral column, and spreads its ramifications to all parts of the body.

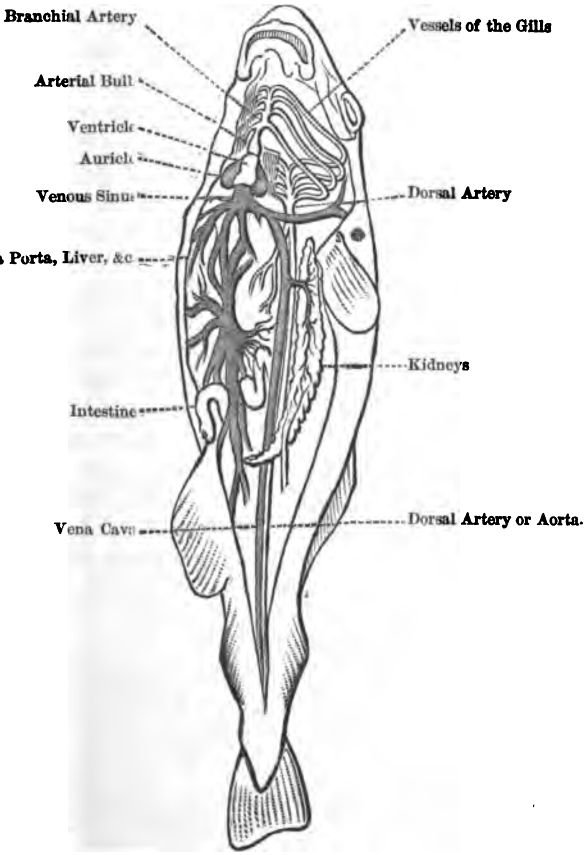


FIG. 258.—CIRCULATING APPARATUS OF FISH.

Finally, the venous blood is not all directly returned into the sinus, which we have before mentioned; for that of the intestines and of some other parts, before being sent back into the heart, is distributed by the portal vein through the liver. We see, then, that the blood, in passing through the circle of the circulation, entirely traverses the respiratory apparatus, as amongst the Mammalia and Birds; but in this course it only passes once into the heart, which consequently renders its progress much slower. The heart itself corresponds in its functions to the right half of the same organ amongst the higher Vertebrata.

536. The Respiration of Fishes is effected by means of the air dissolved in the water; and takes place at the surface of a multitude of projecting and very vascular membranous plates, fixed on the external edge of the branchial arches, the position of which has been already pointed out. In general there are on either side four gills, each composed of two rows of lengthened plates. In several of the Cartilaginous fishes, there are five, and in the Lamprey we find seven. Amongst nearly all the Osseous fishes these plates are simple, and fixed at the bottom only; in a small number, such as the *Hippocampus*, commonly called Sea Horse, they are, on the contrary, ramified, and somewhat resemble bunches of feathers. Lastly, amongst the greater part of the Cartilaginous fishes, such as the Rays and Sharks, they are fixed to the skin by their external edges, as well as to the branchial arches by their internal.

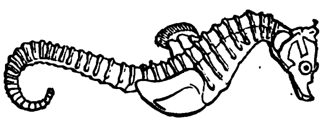


FIG. 259.—HIPPOCAMPUS.

537. The water necessary for respiration enters into the mouth, and by a movement of deglutition is forced through the openings which exist between the branchial arches, and thus arrives at the gills; after bathing the surface of these, it escapes outwards by the opening of the gills. We see, in fact, the animal alternately opening the mouth, and raising its operculum. Amongst those fish whose gills are free at their external edge, it is sufficient to have one of these openings on each side; but when the gills are fixed, it is necessary for the exit of the water to

have an opening for every one of the spaces between the gills. Thus, in the Shark we find five, and in the Lamprey (Fig. 285) seven pairs. We can therefore know the arrangement of the respiratory apparatus, by the single inspection of its external openings. It is also observed that amongst some fishes, the water does not pass directly from the mouth into the respiratory cavity by the openings situated between the branchial arches, but arrives there by a canal situated beneath the œsophagus, something like the trachea of the higher animals; the Lampreys show this kind of structure.

538. Fish consume but a small quantity of oxygen; some, however, are not satisfied with that which is dissolved in the water, and come to the surface from time to time to breathe air. There are even some which make use of it by swallowing it, and converting its oxygen into carbonic acid as it passes along the intestine; the Loach of our ponds shows us an example of this singular phenomenon. When fish remain out of the water, they die in general very quickly from asphyxia; not because they want oxygen; but because the branchial plates, being no longer supported by the water, fall together, and thus cannot so easily be traversed by the blood; and because these organs, when dried up, become unfitted to perform their functions. Thus, the fish that perish the most rapidly by exposure to the air have their gill-openings very wide, which facilitate the evaporation at the surface of the gills; whilst those which resist it the best, have very small apertures, or else possess some receptacle, where they can preserve sufficient water to moisten these organs. The different fish which compose the family of the Labyrinthiform Pharyngeans, are very remarkable in this respect, and owe their name to the cellular reservoirs of

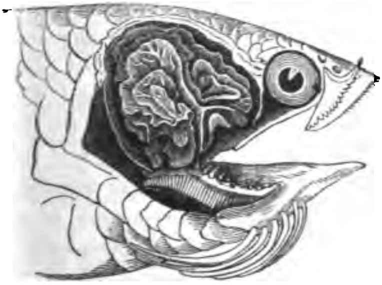


FIG. 260.—RESPIRATORY APPARATUS OF ANABAS.

water placed above their gills. These reservoirs, situated under the operculum, and formed by the plates of the pharyngeal bones, effectually serve to retain a certain quantity of water, which keeps the gills moist when the animal is in the air, and enables it to live there for some time: hence these fish are accustomed to leave the rivers and ponds, which are their usual abode, and convey themselves to considerable distances by crawling in the grass or on the ground. Those which present this labyrinthiform apparatus in its highest degree of complication, and which have received the name of *Anabas*, not only remain very long out of the water, but can even, we are told, climb up trees. The greater part of the fishes of this family inhabit India, China, and the Moluccas. One species, the *Gourami*, which originally belonged to China, and which is much esteemed for its savoury flesh, has been naturalised in the ponds of the Isle of France and of Cayenne.

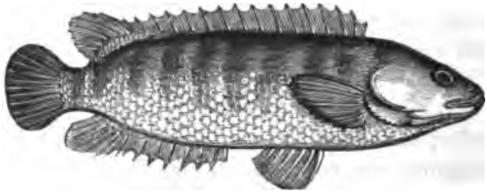


FIG. 261.—ANABAS.

539. As already stated, Fishes produce scarcely any heat; that is, their temperature is usually but little above that of the medium they inhabit. The Tunny, Sword-fish, and their allies, however, constitute an exception to this rule; for they are able to sustain a fixed temperature of about 90°; and they are distinguished from other Fishes by the greater redness of their blood, which results from the larger proportion of red corpuscles. Several of this class have the singular power of developing Electricity, and of giving very strong shocks to the animals which touch them. The Torpedo, the Silurus or Malapterurus, and a species of Gymnotus, are thus constituted; and it is a remarkable thing that the electrical organ presents a very different conformation in each of them.

540. It is the *Gymnotus*, or Electric Eel, which possesses this curious power in the highest degree. It inhabits Southern America; and very much resembles ordinary Eels, except that it has no fins at the end of its tail, and that its skin is without any visible scales. This fish attains about six feet in length; its body is long, and of uniform size, and its skin is covered with a viscid matter. It is very common in the small streams and pools, which are met with here and there in the immense plains situated between the Cordilleras, the Orinoco, and the Banda-Orientalis of South America; and we find it also in the rivers Meta, Apure, and Orinoco.—The electric shocks which it gives at pleasure, and in any direction that it chooses, are sufficient to overcome men and horses; and the Gymnotus has recourse to this means to defend itself against its enemies, and to kill at a distance the fish that it wishes to eat; for water, as well as metals, transmits the benumbing shock of this singular animal,—in the same manner as lightning-conductors convey the electricity of the clouds from the atmosphere to the ground. Its first discharges are in general weak; but when it is irritated and agitated, they become stronger and stronger, and are then terrible. When it has thus struck repeated blows, it becomes exhausted, and requires rest, for a longer or shorter time, before it recovers its power of giving fresh shocks. We are told that it employs this time in reloading its electrical organs, and that the Americans profit by this circumstance to take it without danger. In order to do this, they drive wild horses into the ponds inhabited by these fish; which, receiving their first shocks, are soon stunned and overcome, or even killed; they then seize the exhausted Gymnoti with nets, or with harpoons.

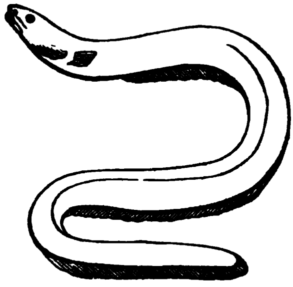


FIG. 262.—GYMNOTUS.

541. The apparatus by which the Gymnotus produces these disturbances lies along the back of the tail, and consists of

four longitudinal bundles, composed of a great number of parallel membranous plates very closely approaching each other; these are nearly horizontal, and are united by an infinite number of other smaller plates placed vertically throughout. The small prismatic and transverse cells formed by the union of these plates, are filled with a gelatinous matter; and the whole apparatus receives very large nerves.

542. The *Torpedo* is a flat cartilaginous fish, very much resembling the common Rays. Its body is smooth, and represents very nearly a circular disc, whose anterior border is formed by two prolongations of the snout, which go on each side to join

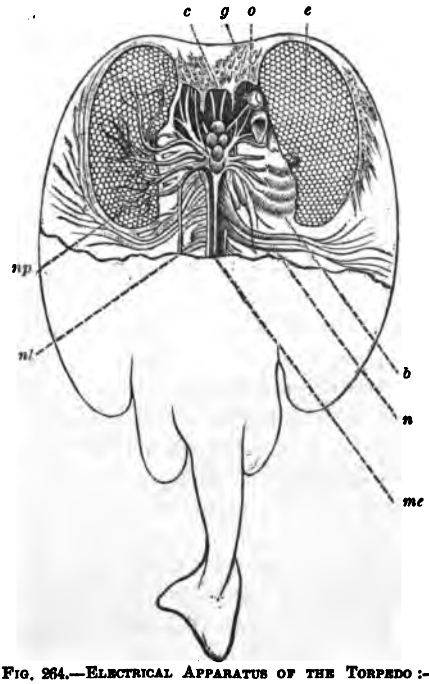


FIG. 264.—ELECTRICAL APPARATUS OF THE TORPEDO :—*c*, brain; *me*, spinal cord; *o*, eye and optic nerve; *e*, electric organs; *np*, pneumo-gastric nerves, proceeding to the electric organ; *nl*, branch from the preceding, covering the lateral nerve; *n*, spinal nerves; *b*, gills.

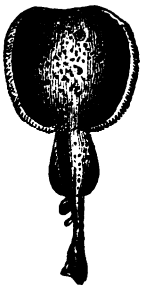


FIG. 263. —COMMON TORPEDO.

the pectoral fins; leaving between these organs, and the head and gills, an oval space, in which is placed the electrical apparatus of these fish. This apparatus is composed of a multitude of membranous vertical tubes, pressed one against the other, like the cells of bees, and subdivided by horizontal partitions into small cells filled with mucous matter; it is supplied by several very large branches of the pneumo-gastric nerves. It is in these singular organs that the electricity is produced, by which the Torpedo can give violent shocks to those who touch them, and produce the same phenomena which in physical experiments result from an ordinary electric current; such as sparks, chemical decompositions, &c. These fish are less powerful than the Gymnotus; but can nevertheless strike with sufficient force to benumb the arms of those who touch them; and it is probably by this means, that they seize their prey. It has been ascertained that this property is dependent on the posterior lobe of the Encephalon; and that by destroying this lobe, or by cutting the nerves which spring from it, the power of producing these shocks is destroyed. Several species exist in the seas which wash the shores of Europe.

543. The electrical *Silurus* or *Malapterurus* inhabits the Nile and the Senegal; its length is from about ten to fourteen inches; and it appears to derive the power of giving electrical shocks from a particular tissue situated between the skin of the sides and the muscles, and having the appearance of a laminated cellular tissue. The Arabs give to this fish the name of *Raasch*, which signifies *thunder*.

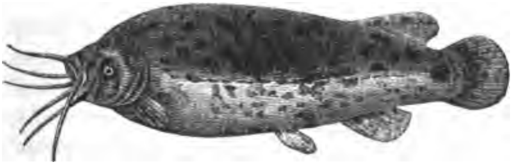


FIG. 265.—ELECTRIC MALAPTERURUS.

544. Fishes multiply by means of eggs; and the number of these is sometimes immense, several hundred-thousands being often produced at a time. In general they have only a mucila-

ginous envelope, and are fertilized after they are laid. Some of these animals are, on the contrary, ovo-viviparous; but whatever may be the manner in which the young fish are brought into life, they are from the moment of their birth completely abandoned to themselves, and many of them perish during the early period of their existence. There are a few species, however, such as the *Gobies*, which make regular nests for their young, composed of sea-weed; and tend them with great care.

545. It is to the simultaneous development of an incalculable number of eggs deposited in the same place, and to the instinct which induces different fish to follow each other, that we are to attribute the union of certain species in immense and closely-packed legions, called by fishermen *shoals of fish*. We can hardly term these unions, *societies;* the individuals of which they are composed do not assist one another; the same wants to be satisfied keep them in the same locality, or remove them from it; and if we see them occasionally following an individual as a guide, it is probably the consequence of a tendency to imitation, which always accompanies the first dawnings of intelligence.

546. However it may be, these animals, thus united in troops, often make long journeys, sometimes to gain the sea, sometimes to ascend rivers or to change their climate. Certain fish lead an almost sedentary life, and remain always in the locality where they were produced; others are always wandering, and a great number of these animals periodically make journeys of greater or less length. At the time for spawning, they generally approach the coasts or enter the rivers; and in this manner they sometimes effect an extremely long passage. Every year, towards the same period, large numbers of migrating fish arrive in the same places; and it is generally believed that several of these species regularly migrate from the north towards the south, and from the south towards the north, following a determined route; but perhaps it would be more true to believe, that when they disappear from the shores, they only retire into the greater depths of the sea. The Herring is one of the most remarkable fishes in this respect, as well as the most celebrated on account of the importance of the fisheries of which

it is the object. It inhabits the northern seas, and arrives every year in innumerable legions upon different parts of the coasts of Europe, Asia, and America, but never descends below the 45th degree of north latitude. Some naturalists think that all these shoals of herrings periodically retire beneath the ice of the polar seas, and set out from this common retreat in an immense column, which, by subdividing itself, is spread out over nearly all the coasts situated above the parallel which we have mentioned. They have even gone so far as to trace upon the chart the journeyings of these shoals; but this long migration, and this common rendezvous in the arctic regions, are far from being demonstrated; and there is reason to believe that these events do not take place in this manner. It is very near our coasts that the herrings deposit their eggs, and it is probable that the young very soon retire into the depth of the sea, and there direct themselves towards the north, where they meet in great abundance with the small Crustacea and Animalculæ, which are fitted to serve them as food. In the spring, other wants bring them towards the shore, and cause them to seek shallower and warmer water. They collect themselves into immense shoals, and descend towards the south; but after having arrived in the Baltic, upon the coasts of Holland, and even as far as Brittany, we do not see them retake the route to the north, to pass the winter under the ice of the pole, and to recommence in the following spring their pretended periodical journey.

547. However this may be, in the months of April and May, Herrings begin to show themselves in the waters of the Isles of Shetland; and, towards the end of June and July, they arrive there in an incalculable number, forming large shoals, which sometimes cover the surface of the sea to an extent of several leagues, and which are several hundred feet in thickness. Soon afterwards, these fish are spread along the coasts of Scotland and England. During the months of September and October, they give place to larger fish; and from the middle of October until the end of the year, they abound on the north coast of France, principally from the Straits of Calais to the mouth of the Seine. In July and August, they generally remain in the

open sea; but they then come into shallower water, and seek a convenient place for laying their eggs, where they remain until towards the month of February. The older Herrings deposit their spawn the first, and the younger ones afterwards; but temperature and other circumstances also appear to have some influence on this phenomenon; for in particular localities, we find eggs during nearly the whole year. After this period they are thin and but little esteemed; fishermen then call them "shotten herrings." Their multiplication is prodigious; there have been found more than sixty thousand eggs in the abdomen of one single female of moderate size. We are told that their spawn sometimes covers the surface of the sea for a great extent, and at a distance appears very much as if saw-dust had been spread there. Very little is known of these fish at an early period.

548. The Pilchard, the Mackerel, the Tunny, and the Anchovy, are also Fish of passage, which periodically visit the coasts, and give rise there to important fisheries. The Salmon is equally remarkable for its voyages: it inhabits all the arctic seas, and every spring it enters the rivers in large numbers, and ascends nearly to their source. In these migrations the Salmon follow a regular order; forming into two long files united in front, and conducted by the largest female, who commences the march, whilst the smaller males form the rear-guard. These troops generally swim with a great noise in the middle of the stream, and near the surface of the water, if the temperature is mild, but nearer the bottom if the heat is great. In general the Salmon advance slowly and by leaping; but if some danger appears to threaten them, the rapidity of their swimming is so great, that the eye can hardly follow them. If a dyke or a cascade opposes their progress, they make the greatest efforts to overcome it. By supporting themselves against a rock, and violently bending their body in a bow, they throw themselves out of the water, and jump sometimes to a height of from 10 to 16 feet into the air, so as to fall again clear of the obstacle which impeded them. The Salmon thus ascend rivers nearly to their source; and then seek in the small streams and quiet places a

bottom of sand and gravel, fit to deposit their eggs. Afterwards, when thinned and weakened by so much fatigue, they descend in autumn to the mouth of the river, in order to pass their winter in the sea. The eggs are deposited in a hole, which the female digs in the sand. The male then comes to fertilise them. The young Salmon grow very quickly; and when they have attained to about the length of a foot, they leave the rivers to proceed to the sea, which they quit in turn to enter the streams, when they have attained the length of 16 or 18 inches, which is towards the middle of the summer that follows their birth. We have already seen that the Swallows, which at the approach of the cold season migrate towards the south, every year return into the same places. It appears that the Salmon has the same instinct. To ascertain this, a naturalist, named Deslandes, placed a ring of copper on the tail of twelve of these fish, and set them at liberty in the river Auzou, in Brittany. Soon afterwards they all disappeared; but the following year, five of these Salmon were caught in the same place; the second year, three; and the year after, three more.

549. The habits of Fish show but few curious peculiarities; but the history of these animals ought nevertheless to interest us, if only on account of the fisheries to which they give origin. At a period which is not very far removed from our own, this branch of industry occupied a fifth of the population of Holland; and for the herring-fishery alone, that country covered all the northern seas with its vessels. In England it has supported a considerable number of good and hardy sailors; and even in France, where it has less importance, there are computed to be thirty or forty thousand fishermen, of which nearly a third venture every year as far as Iceland and Newfoundland to seek for the Cod, a large and excellent fish, which abounds in those parts of the sea, and which is found also, in a comparatively small number, in our own seas.

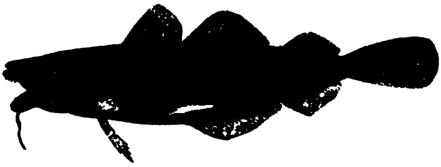


FIG. 266.—COD.

550. The classification of Fishes most generally received is that of Cuvier, who made this group his peculiar study. It is founded upon the condition of the skeleton, and upon the structure and arrangement of the fins. The first division of the class is into the *Osseous* and *Cartilaginous* Fishes; and this division has reference, not merely to the quantity of earthy matter in the skeleton, but to the number of pieces of which the jaws are composed. Although the Osseous Fishes are in many respects the most elevated in the scale, and have the most elaborately-constructed mouth, yet many of the Cartilaginous Fishes surpass them in the development of the cerebral hemispheres, which is probably to be regarded as a measure of their comparative intelligence (ANIM. PHYSIOL. § 452); and we find in many of the latter group, also, a curious modification of the reproductive apparatus, which enables the young animal to derive continued assistance from its parent. Yet it is in this group, also, that we find the very lowest members of the class, in which the vertebrated structure is almost completely lost sight of (§ 519). Thus we may regard the Osseous and Cartilaginous Fishes as forming two parallel series, neither of which can be regarded as above or below the other. Both are connected with the class of Reptiles by some very curious links.

551. The sub-class of Osseous Fishes is divided in the first instance into the groups ACANTHOPTERYGII, or *spiny-finned*, and MALACOPTERYGII, or *soft-finned*, Fishes. In the former, the first portion of the dorsal, or the first dorsal fin (when there are two) always have *spinous* rays (§ 523); of which there are also some in the anal, and at least one in each ventral. In the latter, all the rays, with the occasional exception of the first dorsal or the pectorals, are soft or jointed. The Acanthopterygii cannot be easily again subdivided, except into families; but the Malacopterygii may be divided into three orders, according to the position of the ventral fins. If these are situated under the abdomen, the fishes are *Abdominal;* if attached to the shoulder, they are *Sub-brachial;* and if wanting, they are *Apodal.* Each of these orders, especially the first, contains numerous families.

552. The sub-class of Cartilaginous Fishes is primarily

divided into those having the extremities of the gill-filaments unattached (as in Osseous Fishes); and those having them fixed. The former group constitutes but a single order; but the latter is again subdivided into those which have the jaws moveable and adapted for mastication; and those which have them soldered into a ring for suction. The latter are termed *Cyclostomi*, or circular-mouthed Fishes.

553. The following Table will perhaps enable this arrangement to be more easily understood. We shall presently find, however, that there are one or two small groups not included in it, which are separated from the rest by characters so remarkable, as perhaps to entitle them to be ranked as distinct orders.

OSSEOUS	*Acanthopterygii*, spiny-rayed		*Acanthopterygii*.
	Malacopterygii, soft-rayed	ventral fins beneath abdomen	*Abdominales*.
		ventral fins beneath shoulder	*Sub-brachiati*.
		without ventral fins	*Apoda*.
CARTILAGINOUS	gills free		*Sturiones*.
	gills fixed	jaws moveable	*Plagiostomi*.
		jaws soldered	*Cyclostomi*.

554. The class of Fishes is probably the most numerous of the whole Vertebrated series, both in regard to the number of families, genera, and species which it contains, and in regard to the number of individuals of the same species. The structure of a very large proportion of it has been but very imperfectly investigated; and of the habits of these animals still less is known. Instead, therefore, of giving a technical description of every family, such as will be found in Systematic Treatises on Zoology, we shall confine ourselves to a notice of those groups which are of most general interest, either on account of peculiarities in their structure, or their importance to Man. It has been calculated that, exclusive of lakes and rivers, the seas occupy full seven-tenths of the earth's surface. These seas yield food even to the depth of several hundred feet; and, as there is no obstacle in the water to bar the movements of Fish, we see that their pasture-grounds are almost unlimited in extent. Different tribes are formed to inhabit different situations; thus we have some Fish adapted to live in fresh-water only,—others

which can only live in salt-water,—and others, again, which can pass from the one to the other without inconvenience. Of fresh-water fishes, some are the inhabitants of rivers, others of lakes, whilst others prefer small streams. Of the marine fishes, some keep near the shore, whilst others pass most of their lives in the open sea; some, again, float near the surface; whilst others never rise much above the bottom. It is probable that we might regard the deeper parts of the ocean as divided (so to speak) into *strata*, each tenanted by certain species of fish; for it is quite certain, that there is a particular range of depth, in which each species is usually found, and beyond which it seldom strays, either towards the surface or the bottom of the ocean. It is among the Fishes of shallow waters, and those which habitually tenant the higher stratum of the deep seas, that we find the most beautiful display of colours; those of deep waters are for the most part comparatively dull in tint. This difference is probably due to the absence of light, which seems necessary to the development of the most brilliant colours; for the diminution in the intensity of the sun's rays, as they traverse water, is very rapid. What may be the absolute depth of water, at which all light ceases, and death and darkness reign, we have no direct means of ascertaining. It varies, of course, with the latitude; since, the more obliquely the sun's rays fall upon the water, the less will be the depth to which they will penetrate.

ORDER I.—ACANTHOPTERYGII.

555. Of this Order, one of the principal families is that of PERCIDÆ, or *Perches;* of which the common *Perch* of this country may be taken as an example. In this group, the body is oblong, and covered with hard or rough scales; and the opercular bone is edged with spines or small teeth, which do not, however, extend over the cheek. The Perch is one of our most common fresh-water fishes, abounding in rivers, lakes, and ponds, especially such as are clear, and lurking under the banks, or swimming near the surface. It is spread throughout the

whole of temperate Europe, and is even found in Lapland; other species are found in America, and in the tropical parts of the Old World. The food of the Perch consists of insects, worms, and small fishes, which it devours with great voracity; and it may be rendered sufficiently tame, to take these from the hand. Like the Carp, it is very tenacious of life; and will live for many hours if packed in wet moss, and occasionally refreshed with water. The *Basse* is a marine fish, nearly allied to the Perch in its general structure; it is found on the whole line of our southern coast; and associates in shoals, which at the spawning time frequent the mouths of rivers, and even advance up the stream to a considerable distance. It will not only live but thrive in fresh-water, if well supplied with food; which, in its natural haunts, consists of small fishes and crustaceans. In these, and other species, the ventral fins are placed immediately beneath the pectoral (Fig. 246); and Fish in which this arrangement exists, are characterised as *thoracic*.—Other Percidæ, however, have the ventrals situated upon the throat, further forward than the pectorals; such are said to be *jugular*. In this group we find the *Trachinus* or *Weever*, which has the first ray of the dorsal fin extended into a very long spine, and has also a strong spine on each operculum. This fish lies in the mud, and inflicts severe wounds with its dorsal spine, which the fishermen believe to have a poisonous power; the bad character of the wound, however, merely results from the rugged nature of the instrument which inflicts it. Something of the same kind is the case with the Perch; the sharp spines in its dorsal fin having been known to lacerate the fingers of those who handle them incautiously.—Another curious genus of this second group is the *Uranoscopus*, or Star-gazer; só called because the eyes are situated on the upper surface of the nearly cubical head, and directed towards the heavens. Within the mouth, behind the tongue, is a long narrow slip, which the fish can protrude; and which serves as a bait to attract the small fishes on which it preys, whilst it is itself concealed in the mud. One species inhabits the Mediterranean; but none of the others are eaten.—A third division of the Percidæ comprises those which are *abdominal*, having the ventral fins behind the pectorals. This group includes the genus *Polynemus*, which is characterised by the very curious extension of the rays of the pectoral fins into long filaments, which hang loosely on each side of the body, being sometimes prolonged to twice its length, and giving it a very beautiful appearance. The fishes of this genus are found in the seas and rivers of tropical countries; they are usually very brilliant in their colours; and they are regarded as most delicious articles of food. The Mango-fish of the Ganges is a species of this genus; as is also the Suleah-fish of Bengal, to which attention has recently been directed, as affording in its air-bladder a large supply of excellent isinglass.—Besides the foregoing, there is a group of Percidæ, in which the ventral fins are placed still further backwards; these are for the most part marine fishes, some of them inhabiting our own coasts, and others of larger size being natives of tropical seas. Among the former is the *Mullus* or *Surmullet;* which has been in great repute among epicures from the time of the Romans, who used to feast their eyes upon the changes of colour which the Red Mullet undergoes in dying, before they devoured its flesh. This genus is quite distinct from that of the *Mullets* properly so called. Of the tropical species one of the most remarkable is the *Barracuda*, a large and voracious fish, which is nearly as much dreaded in some places as the Shark; it is, however, a very palatable article of food.

556. The next group includes a large number of Fishes nearly allied to the Perches, but having the head defended by spines and hard scaly plates. First among these we may mention the *Triglæ* or *Gurnards;* of which we have several species on our own coasts; they are known by the squared form of their heads, which are covered with bony plates. The pectoral fins are usually large; and in an allied genus, the *Dactylopterus*, or Flying Gurnard, they are of sufficient size to support the animal for a time out of the water (Fig. 250). The Gurnards emit a curious grunting or croaking noise at intervals, when taken out of the sea; and this they continue for some time. They are very tenacious of life; and mostly swim near the

bottom of the water. The swimming-bladder is usually large, and furnished with powerful muscles for its compression. To this group also belongs the genus *Cottus*, or Bull-head, which has a large and horizontally-flattened head, eyes looking upwards, and its skin almost destitute of scales, and of a dusky hue: it lurks among stones in the beds of rivulets; and its food consists of aquatic insects or small worms. The *Scorpæna*, or Hog-fish, has the head flattened sideways, and armed with spines; it is a marine fish, associating in shoals, and haunting the rocky shores. Allied to this is the *Sebastes*, or *Norway Haddock*, which inhabits the northern seas, and is an important article of food; the Greenlanders use its long spines as needles. Also belonging to this group is the *Gasterosteus*, or Stickleback, of which there are several species, some inhabiting salt water, and others fresh. The body has no proper scales, but is more or less plated at the sides; and the abdomen is covered by a sort of cuirass, formed by a union of the pelvic and humeral bones. The common name of these fish is derived from the circumstance, that instead of possessing two dorsal fins, it has only one, the anterior being replaced by a set of sharp spines varying in number; whilst the ventral fin is in the form of a sharp spine without any rays. These fishes are active and rapacious, attacking other fishes with great ferocity, and devouring almost any small animal that comes within their reach. The *Fifteen-spined Stickleback* has been seen to undergo remarkable changes in its hue, under the influence of terror.

557. We may pass over the SCIÆNIDÆ, or *Maigres*, and the SPARIDÆ, or *Sea-Breams*, to notice the SQUAMIPENNES, or *Scaly-finned* fishes; which are thus designated, from the soft, and even the spiny, portion of the dorsal fins being so covered with scales, as not to be easily distinguished from the rest of their bodies. The body, too, is usually itself much compressed, or flattened laterally. The *Chætodons*, which constitute the types of this family, are beautifully-coloured fishes of singular figure, abounding in the seas of the hotter climates. Their most common tints are black and yellow; but metallic blues and greens are not unfrequent. Sometimes the colours are disposed in spots; but

mostly in stripes or bands. They generally haunt rocky shores; and their flesh is considered excellent food. One species of this genus, the *Chætodon rostratus*, is remarkable for the manner in which it obtains its insect prey, by shooting drops of water from its long snout, so as to bring them down within its reach. Another fish of the same family, called the Archer, will in this manner shoot drops of water to the distance of three or four feet, rarely missing its aim. These fish inhabit the seas around Java; and other species are found in different parts of the Indian seas.

558. The next family, SCOMBERIDEÆ, or the *Mackerel* tribe, is one of the greatest importance to Man, from the large supply of wholesome and palatable food which it affords him. It consists of a number of species varying considerably in size; but distinguished by possessing a smooth skin, covered with a multitude of small scales; and by having a large and vigorous tail and caudal fin. They are divided into several groups, according to the form of the fins, tail, &c. In the first of these are associated the common *Mackerel*, the *Tunny*, and others, which are distinguished by having the hinder rays of the dorsal and anal fins separated into small fins. The Mackerel is remarkable for the beauty of its colours, in which it is almost pre-eminent among British fishes; and for the rapidity with which it dies and becomes tainted, when removed from the water. The periodical appearance of large shoals of this fish upon our coasts, was formerly imputed to its migration from north to south. But many facts are opposed to this idea; and there can be little doubt that it is an inhabitant of the deeper parts of the seas around our island through the whole year, and that its appearance on our coasts is solely due to its seeking the shore, for the purpose of depositing its spawn. It is during the months of May and June that this takes place; and these months, therefore, constitute the most active season for Mackerel fishing. This fish is most abundant on the southern coasts of England; but instances have been mentioned, in which large shoals have been met with even off the coast of Greenland.—The *Tunny* is

a rare fish on the shores of Britain; but it is very plentiful in the Mediterranean, and has been known and celebrated from the remotest period of antiquity, at which we have any mention of Fish by particular names. It is a far larger and stouter fish than the Mackarel, though bearing a general resemblance to it in form; a specimen which was caught when chasing Herrings into Loch Fyne, measured 7 ft. 10 in. in length, and weighed 460 lbs. The Tunnies, like the Mackarel, are dispersed through the ocean during most of the year; but in the summer they resort to the shores in vast shoals; and a fishery of great importance is then carried on along the north coast of the Mediterranean, and in the island of Sicily. The flesh of the Tunny, both fresh and salted, forms a considerable part of the food of the common people of those shores; and the fishery constitutes a large source of profit to those who reside on the coasts. The *Bonito* or *Striped Tunny*, also a native of the Mediterranean, and a rare visitant on our shores, is a very handsome fish, though smaller than the common Tunny; it is further distinguished by its great activity and voracity, being one of the chief enemies of the Flying-fish; and, in common with the Tunny, it can sustain a higher temperature than most other members of its class.

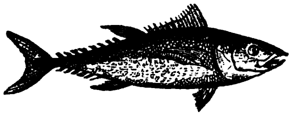


FIG. 267.—TUNNY.

558*. Another remarkable group of this family consists of the *Sword-fish* and its allies, which have the muzzle elongated into a spike, which terminates in a sharp point, and constitutes a very formidable weapon. These fishes, of which there are several species, are usually furnished with a high dorsal fin, by the agency of which they are enabled to propel themselves through the water with great energy. They sometimes attain the length of 12 or even

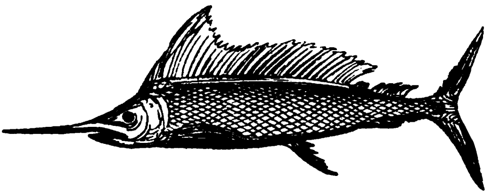


FIG. 268.—SWORD-FISH.

15 feet; and they do not hesitate in attacking very large fishes (the Tunny, for example), transfixing them with their powerful spear. Instances are on record, in which even Men have been thus destroyed; and it has not unfrequently happened that a Sword-fish has struck a ship, and has driven its sharp weapon through the planking. In the Mediterranean, where one species of Sword-fish is not uncommon, it is regularly pursued by the fishermen; and its flesh is much esteemed in some places as an article of food. It is seldom seen, however, in large numbers together.—A third group of the Scomberideæ is characterised by having the rays of the first dorsal fin not connected, but existing as separate spines. Of this group we shall only stop to notice the *Pilot-fish;* which has been, from very ancient times, the subject of many fictitious statements. By the ancients it was regarded as a sacred fish, from its being supposed to indicate their true direction to doubtful voyagers; whilst, by sailors of the present day, it is commonly regarded as a guide to the Shark in its pursuit of prey, and is said to tempt it to take the bait which has been thrown out for its capture. Certain it is, however, that the Pilot-fish will often follow in the wake of ships for many hundred miles; thus an instance has been known, in which a vessel was accompanied by two of this species, during its whole voyage from Alexandria to Plymouth, which occupied 87 days. The common Pilot-fish of the Mediterranean and Atlantic does not much exceed a foot in length; but there is a species on the South American coast, which occasionally attains eight or nine times those dimensions.

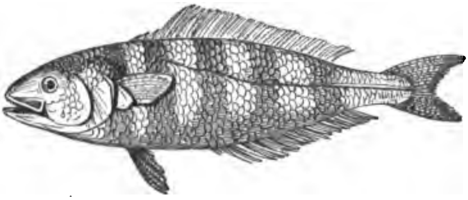


FIG. 269.—PILOT-FISH.

559. The family ZEIDÆ strongly resembles the preceding; but differs from it in the high and compressed form of the body. Many of the species composing it are remarkable for the filamentous prolongations of their fins. This is the case with one

of the types of the family, the *Zeus* or *Dory*, the peculiar form and aspect of which will be better understood from the accompanying figure, than from any technical distinction. This fish has been in great repute amongst epicures, even from the time of the Romans; it is not very common upon our own coasts, being nearly restricted to Devon and Cornwall; but it is more abundant in warmer latitudes. The name *John Dory*, by which it is commonly known in this country, is evidently a corruption of the French *jaune doré*, or gold and yellow; which applies to the colour of its lighter parts when

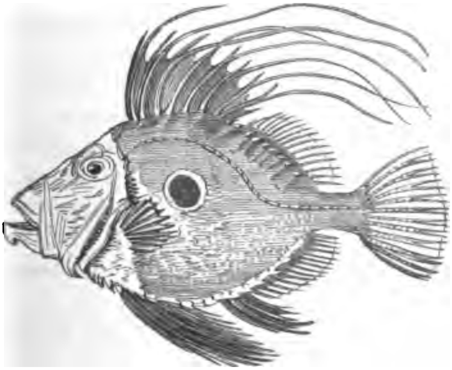


FIG. 270.—THE DORY.

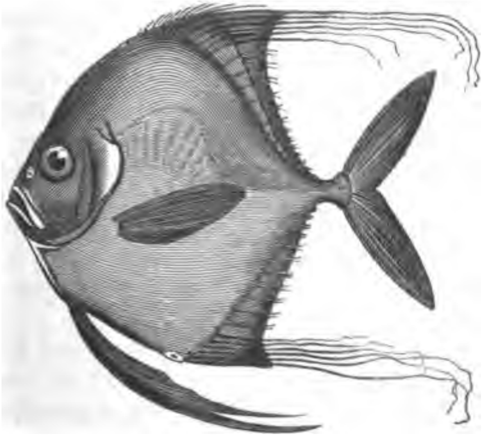


FIG. 271.—BLEPHARIS.

the fish is alive.—Another fish of this family, no less remarkable for its form, is the *Blepharis;* of which one species, inhabiting the West Indian seas, is known under the appellation of the *Cobbler-fish,* probably on account of the long thread-like appendages for which it is so conspicuous. The use of these curious appendages is altogether unknown.—With this family may also be ranked the *Coryphæna,* or *Dolphin* of the ancients; which is a large and splendidly-coloured fish; celebrated for the velocity of its movements, and for the variety of tint which its surface exhibits under a play of light. The changes of hue which it undergoes when dying, were a source of great enjoyment to the luxurious Romans; by whose poets this Fish was much celebrated. The Dolphin of the moderns is not a Fish at all, but a Cetaceous Mammal (§ 211).

560. The two succeeding families,—TÆNIDÆ, or *Ribbon-shaped Fish,*—and THEUTIDÆ, or *Lancet-fish,*—must be passed over with but slight notice. The peculiar characters of the former are indicated by their name; the species of which it consists (some of them bearing a very close resemblance to the Scomberideæ), being distinguished by their lengthened bodies, much flattened at the sides, and having very small scales.—The *Lancet-fish* combine the small scales of the Scomberoid family with the form and small mouth of the Chætodon; but their fins are not scaly, like those of the latter. They are among the few Fishes, which live on sea-weeds and other marine vegetables. Several of the genera have sharp spines on the sides of the tail, which they can draw back into a groove; with these they can inflict severe wounds upon the hands of those who touch them incautiously; but they are peaceful in their habits, never voluntarily making an attack, but contenting themselves with repelling the assaults of their enemies.

561. The peculiar structure of the succeeding family, ANABASIDÆ, has been already mentioned (§ 538); and it adapts them to a mode of life which the circumstances of this climate do not render necessary. In cold or temperate regions, the ponds and streams, which are capable of supporting fish at all, are not dried up, except in seasons of extreme drought: but in tropical coun-

tries there are many situations, in which there is an ample supply both of food and water for Fish during the rainy season; but a complete deficiency of both, when this is succeeded by the periodical drought. Such receptacles can only be tenanted by Fish, which, like the Anabas, are furnished with the peculiar pharyngeal apparatus (Fig. 260) for keeping the gills moist; since, when one pond or stream is dried up, they can migrate in search of another. In the course of these journeys, they climb up steep banks, and even trees; and by a remarkable instinct, they seem always to travel towards the nearest water. This family contains a considerable number of genera, all of which are inhabitants of fresh-water; none have been hitherto found except in the south-east of Asia and the adjacent islands, and in Southern Africa.

562. This family is succeeded by that of Mugilidæ, or the true *Mullets;* which are distinguished by several remarkable peculiarities of structure. Their body is nearly cylindrical, and is covered with large scales; the head is broad and flat, and is covered with large angular scaly plates; and the stomach is furnished with fleshy walls, giving it a resemblance to the gizzard of a Bird. The Mullets associate in large shoals, and chiefly inhabit the mouths of rivers, where they are often seen making high leaps. They feed upon small Crabs and other Crustacea, which they swallow entire; and the almost total want of teeth is compensated by the powerful gizzard, which serves to grind down their food. The Grey Mullet is one of those fishes, which,—habitually living at the mouths of rivers, where the salt and fresh waters mix,—will thrive well in the latter alone.

563. We may next mention the Blennidæ, or *Blennies*, which are elongated Fishes, having a single dorsal fin, almost entirely supported upon simple flexible rays. The ventral fins are placed in front of the pectorals, and have only two or three rays in each. They live in small troops near the coast; and they can exist for some time without water (their gill openings being small), especially if kept in moist grass. Many of this family retain their eggs until they are hatched within the oviduct; so that the young are produced alive, fully formed, and capable of subsisting

for themselves. The *Anarrhicas*, or Sea-Wolf, must be referred to this family, although differing from it in possessing no ventral fins, and in having the jaws and palate armed with large tubercular teeth. — This fish may be almost regarded as replacing the Sharks in the Arctic seas; for it attains the length of six or seven feet, and is extremely voracious and bold. Its body, though massive, is adapted for active and energetic motion; and its powerful bite makes it a very formidable enemy. It often enters the fishermen's nets, for the purpose of plundering them of the entangled fish; and when the fishermen attack it, and it cannot dart through the net, it fights like a Lion. On the east coast of Scotland it is not an unfrequent visitor; and its appearance and habits cause it to be regarded with great dislike; nevertheless its flesh is wholesome and palatable. It is understood to prey indiscriminately upon Fishes, Crustacea, and shelled Mollusca; its jaws and teeth being capable of breaking the hardest shell. In the family Gobidæ, or *Gobies*, we find the same simple flexible rays in the dorsal fin, as in the preceding group; but the ventral fins are united beneath the chest, forming a sort of conical sucker, which the Fish seem to use for the purpose of occasionally attaching themselves to solid bodies. They live, like the Blen-

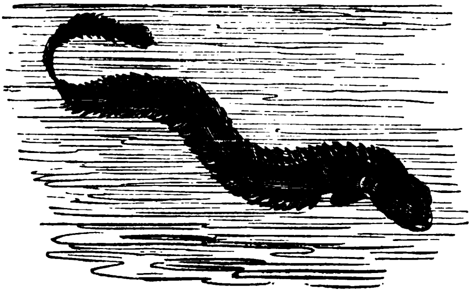


Fig. 272.—Blenny.

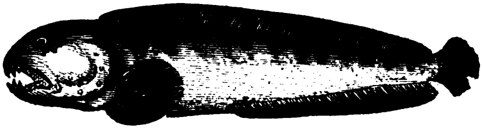


Fig. 273.—Anarrhicas Lupus.

nies, near the shore, and prefer a clayey bottom, in which they excavate canals, wherein they pass the winter. In spring, they prepare a sort of nest, with sea-weed; in which the young (often produced alive, as in the Blennies) are protected; and the parents exert themselves considerably to bring them food and to defend them from their enemies. Several species of Goby exist in the European seas; but none of them are of much size, or of any direct value to Man. In other seas numerous genera exist, more or less allied to the Gobies of our own coasts.

564. There are certain spiny-finned Fishes, in which the carpal bones are so elongated, as to form a sort of arm or wrist, to the extremity of which the pectoral fin is articulated. This conformation (an approach to which is seen among some of the Gobies) gives to the Fishes which possess it a very strange appearance; and enables them, in some instances, to leap up suddenly in the water, and seize the prey which they observe above them; in other cases to leap over the mud, somewhat after the manner of Frogs. From the very peculiar genus *Lophius*, or *Fishing Frog*, in which this character is combined with some others of a very extraordinary nature, the family may be designated as that of LOPHIADÆ, or *Anglers*. The common Angler of our own coasts has an enormous flattened head, which constitutes the chief bulk of the Fish; and a tail so compressed on each side, that the creature seems composed of little else than head and tail. On the former, in front of the eyes, are two long rays or filaments of a horny substance; and there are also four others of a similar nature, but shorter, on the head. The mouth also is furnished with numerous worm-like appendages; which seem to represent the tentacula or prolonged lips of many Invertebrated animals. This animal is described as concealing itself amongst marine plants, or behind hillocks of sand, rocks and stones; when it opens its great mouth and attracts small fishes as they swim past, by giving a wriggling motion to the appendages just mentioned, which causes them to mistake these for worms; so that, in attempting to seize them, they fall an easy prey to their subtle and voracious enemy, being speedily engulfed between its enormous jaws. The

hideous appearance of its monstrous and constantly-open mouth, well armed with teeth, has gained for the Angler the vulgar name of Sea Devil. There are few parts of the British shores where it is not to be occasionally met with; and when captured in nets along with other fishes, it speedily begins to swallow its companions. On some coasts it is sought for, on account of the live fish in its stomach. In the Museum of the College of Surgeons in Dublin, there is a skeleton of an Angler, about two feet and a half in length, in the stomach of which is the skeleton of a Cod, two feet long,—in whose stomach again are contained the skeletons of two Whitings of the ordinary size,—and in the stomach of each Whiting there lay, when it was first examined, numerous half-digested little fishes, which were, however, too small and broken-down to admit of preservation. The Frog-fish, with all these contents, had been taken by the fishermen, and offered for sale in the market as an article of food, without any reference at all to the size of its stomach, which was not at all unusual. The contained fishes must have been all swallowed on the morning on which the Angler was taken; as they were all, with the exception of the smallest, equally fresh and undigested.—The *Chironectes*, or Hand-fish, bears a strong resemblance to the common Angler in its structure and habits; but its fins are still more capable of motion, enabling it to walk along the ground almost in the manner of quadrupeds,—the ventral fins, however, in consequence of their advanced position, serving as the fore-legs, and the pectoral fins performing the office of hind-legs. In some of the muddy estuaries of the north coast of Australia, from which the tide ebbs far back in the dry season, these Frog-fishes are abundant, and capable of taking such vigorous leaps, that those who have visited these places have, at first sight, mistaken them for birds. Their gill openings are very small; and they can live out of the water for two or three days. They have the faculty of inflating their large stomachs with air, so as to give themselves the form of a balloon,—in this respect corresponding with the Diodon.

565. The Labridæ, *Wrasse* or *Rock-fish* family, are chiefly remarkable for their thick fleshy lips; their jaws are armed with

large teeth, and their colours are for the most part very brilliant. Several species are found upon our own coasts, but they are not in much repute, and are known among the fishermen by the name of "Old Wives of the Sea." They chiefly frequent rocky shores, as their name implies.—This family also includes the remarkable genus *Scarus* or Parrot-fish; which is furnished with large convex rounded jaws, and these are covered with hard, scale-like teeth, which succeed each other from the rear to the front in such a manner, that the bases of the newest form a cutting edge. Numerous species of these fish inhabit tropical seas; many of them are remarkable for the brilliancy of their colours, whence, perhaps, their ordinary name has been derived. These Fishes appear destined to restrain the extension of the stony Corals, on the newest layers of which they are enabled, by the immense strength of their jaws and teeth, to browse without difficulty,—digesting the animal matter it contains, and setting free the carbonate of lime in a chalky state.

566. The last family of Acanthopterygii is that of FISTULARIDÆ, or *pipe-mouthed* Fishes; so named from the curious conformation of the head, which is furnished with a long tube projecting forwards, and having the mouth with its jaws at the extremity of this. There is no other point, however, in regard to which they demand peculiar notice.

ORDER II.—MALACOPTERYGII ABDOMINALES.

567. The CYPRINIDÆ, or *Carp* tribe, constitute the first family of this order; they are characterised by their small mouth, and by their feeble and generally toothless jaws; but they have the pharynx strongly toothed, which compensates in some degree for the feeble armature of the jaws. They are for the most part fresh-water fishes, and live on aquatic plants. These are masticated in the pharynx, which is a powerful instrument of reduction, being furnished with strong muscles, that bruise the food between its teeth and a stony disc fixed at the base of the skull. The common *Carp* was not originally a native of

this country, but was introduced from the South of Europe; it thrives very well, however, in the most slow-running parts of rivers, and still better in ponds, sometimes attaining the length of four feet. The beautiful little *Gold* and *Silver Fish*, belong to a small species of Carp, which is very much disposed to pass into varieties. Nearly allied to these are the *Barbel*, which sometimes attains the length of ten feet; it inhabits ponds and sluggish streams; and is said to plough up the mud with its long snout, so as to set adrift in the water the minute animals imbedded in it, and thus to attract the small fishes on which it is itself supported. The *Gudgeon*, *Tench*, *Bream*, *Roach*, *Bleak*, *Minnow*, and many other well-known pond and river-fishes, belong to this family; as do also the *Loach*, which habitually buries itself in mud when the weather is cold; and the *Anableps*, which is remarkable for being apparently possessed of four eyes. This is not, however, really the case; for although the cornea and iris are divided by transverse bands, so that there are two *pupils* on each side (ANIM. PHYSIOL. § 533), yet the other parts of the eye are single. The female of this species brings forth her young alive, in a state of considerable advancement.

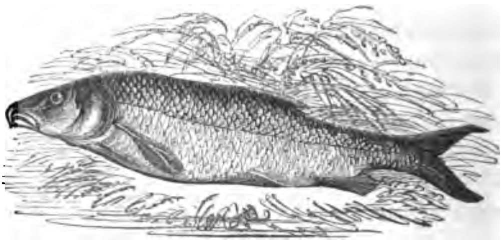


FIG. 274.—BARBEL.

568. The family ESOCIDÆ, or *Pike* tribe, is nearly allied to the preceding; but differs in having the jaws and palate usually beset with teeth, and in the voracity of the fishes which it includes. Many of these are inhabitants of fresh waters; others occasionally ascend rivers; whilst others again are confined to the sea. The common *Pike* is well known as being one of the most voracious

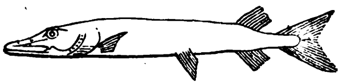


FIG. 275.—PIKE.

and destructive of all the smaller fishes. Mr. Jesse mentions, that eight Pike, of about 5 lbs. weight each, consumed nearly eight hundred Gudgeons in three weeks; and that one of these devoured five Roach, each about four inches in length, within a quarter of an hour. The Pike not only makes havoc among other fish, but will devour frogs, water-rats, field-mice, and the smaller aquatic birds; and instances are on record, in which it has even attacked Man. It grows rapidly, and sometimes attains the weight of more than 30 lbs. It is a very long-lived fish,—having been known to attain the age of 90 years,—and having in one instance (there is reason to believe) lived to the patriarchal age of 267 years, and attained the length of nineteen feet.—The *Gar-fish*, or *Sea-Pike*, has a much more elongated mouth, which is not so well furnished with teeth. It is quick and active in the water; swimming with considerable rapidity near the surface, and leaping and gambolling as if in the exuberance of vivacity. This fish comes in shoals to the southern coast of Britain, in the months of April and May; and from its appearing a short time before the Mackarel, it is termed by the fishermen the Mackarel-guide. It is not in much esteem as an article of food.—To this group also belongs the *Exocetus*, best known as the *Flying-fish;* which is remarkable for the enormous development of its pectoral fins, and for its power of sustaining itself upon them out of water. It is necessary to bear in mind that the term *Flying-fish* has been applied to this genus, in common with the *Flying Gurnard* (§ 555); and that, although really so different, they have been continually confounded together in the accounts of voyagers. The term Flying-fish ought to be restricted to the Exocetus; which is the one that best deserves it. Various species exist in different parts of the seas of warm latitudes; and our own coast has been occasionally visited by them. As elsewhere stated (ANIM. PHYSIOL. § 667), their flight through the air seems entirely to depend upon the impulse they receive from the stroke of their fins upon the water, at the moment of quitting it. They are to a certain degree *supported* by their wing-like fins, while sailing through the air; but they do not seem able to raise or to propel themselves by striking them against it. The most usual height of their flight is from two to three feet; but they have occasionally been known to spring to a height of fifteen or even twenty feet. The utmost length of their flight seems to be between two and three hundred feet; and its extreme duration about thirty seconds. Few spectacles are more beautiful, than the sudden rise of a shoal of Flying-fish from the gently-undulating surface of the tropical ocean,—their scaly surface and extended fins glistening in the bright sunshine with all the varied hues of the rainbow,—and the graceful curves in which they move at last terminated by a return to their native element, from which they presently again spring up with renewed vigour. These airy excursions are commonly regarded as occasioned by the pursuit of Dorados, Bonitos, and other fishes of prey; but this is probably by no means the case, for the Flying-fish seem frequently to rise from the water for the mere sake of exercising, with pleasure to themselves, those powers of movement with which they are endowed,—just as we see other fishes gambolling about in their usual medium. Whilst in the air, they are often seized upon by the long-winged sea-birds.

569. The next family, SILURIDÆ, or *Silure* tribe, is distintinguished by the want of scales, having only a naked skin, in which large bony plates are frequently imbedded. Many of them have the adipose or fatty second dorsal fin, which is a prominent character of the next family. The species included in this group are mostly river-fish, of considerable size, inhabiting warm climates. Many of them have the first ray of the pectoral fin very strong and bony; and the fish can, at pleasure, lay it flat on the body, or keep it fixed in a perpendicular direction, in which case it becomes a formidable weapon, capable of inflicting very troublesome wounds. There is no sufficient reason, however, to believe that these wounds are venomous.—The *Malapterurus*, remarkable for its electrical powers, has been already noticed (§ 543).

570. The two remaining groups of this order are of great importance to Man, from the large supply of wholesome and palatable food which they yield. The first of these is the family SALMONIDÆ, or *Salmon* and *Trout* tribe; which is characterised

by having all the rays of the first dorsal fin soft or jointed; and the second dorsal entirely adipose, being merely a fold of skin inclosing fat. The species of this family are at once distinguished from the Siluridæ, by having the body covered with scales; they are generally very muscular, and possessed of great strength; and they are voracious in their habits, feeding rather upon Insects, small Crustacea, &c., than upon other Fishes. The different subdivisions of the group vary considerably in regard to the position of the fins, and the degree in which the mouth is armed with teeth. Most of them frequent the estuaries of rivers, and ascend the stream at regular periods to deposit their spawn in its higher parts; and it has been ascertained that the same fish and their descendants resort in successive years to one particular locality. Nearly all the members of the family are clouded with transverse dusky patches when very young, and undergo considerable changes in their livery before they arrive at their full growth. Hence there is much difficulty in determining their species; which is increased by the circumstance, that the male, in many instances, appears to be capable of propagation long before arriving at its full growth. The *Salmon* of our own rivers is one of the largest of the whole family; but in consequence of the eagerness with which it is pursued by fishermen, it does not often attain its full size in this country. Enormous specimens, however, are now and then captured; a weight of 40 lbs. does not seem very uncommon; and in 1821, a specimen was exhibited in London, weighing 83 lbs. The usual time at which the Salmon leaves the sea, is the autumn; it remains in the rivers during the winter; and returns to the sea, after having deposited the spawn, in the spring. The young fry, termed Smalts, are carried down to the sea in the months of April and May. In some rivers, however, they do not make their ascent until the winter; and in others they even delay it until the spring. These variations appear to depend upon differences of temperature in the rivers themselves; since, when these are very cold, the fish avoid passing the winter in them. Before depositing its spawn, the Salmon makes a furrow with its nose in the gravelly bed of the river; and its eggs, when deposited in this, are carefully covered up. The common *Trout* is entirely a fresh-water fish, delighting in rivers which have a rapid current, and abounding also in many stream-fed lakes; it lurks during the day in the deep pools, under the shadow of large stones, or under precipitous banks; and becomes active towards evening, when it begins eagerly to pursue its prey, which seems to consist especially of Insects and aquatic Larvæ, and of small Crustacea,—but also of small fishes, and the ova of the larger ones.—The *Char* is considered as having the most delicate flavour of any of the fishes of this family; it is a lake fish, and is not very common in this country.—The *Smelt* resembles the Salmon in its habits, but is much smaller; it has been found, however, to thrive very well when confined to fresh water.—Several other genera exist in various parts of the world; some of them approach other families in their general structure, and are exclusively marine in their habits.

571. The only remaining family of this order is that of CLUPEIDÆ, or *Herrings*, and their allies. These have a scaly body like the Salmon's, but no adipose dorsal fin; and there is also a difference in the arrangement of the bones of the jaws. They are for the most part marine fishes; only a few species, as the Shad and White Bait, ascending rivers periodically like the Salmon. The habits of the common *Herring*, in regard to its reputed migrations, have been already noticed (§ 546); notwithstanding the very circumstantial account given by Pennant, and copied by later authors, it seems now to be well established that the only migration of the Herring is from the deep seas to the shores at the spawning season, and from the shores to the deep seas when this is over. It is a curious and perplexing circumstance, that the shoals of Herrings do not continue to resort to the same localities; but that they will leave some parts of the coast which they had been accustomed to visit with regularity, and will make their appearance on others which they had not previously frequented. Their food consists of small Crustacea and Fishes; and it appears that they do not spare the young of their own race, five small herrings having been found in the stomach of a large female. They usually swim near the surface of the water;

and, like other fishes whose habit is the same, their gill-openings are large, their respiration considerable in amount, their muscular energy great, and their demand for oxygen so constant, that, when taken out of the water, they speedily die. The *Pilchard*, *Sprat*, *Shad*, *White-Bait*, *Sardine*, and *Anchovy*, are all more or less closely allied to the Herring,—the last departing from it most widely. The range of the Pilchard, which abounds on the Cornish coast, is more southern than that of the Herring; and the Anchovy and Sardine replace the Herring in the Mediterranean, where it is unknown. The importance of the Herring and Pilchard Fisheries is very great. Some notion of it may be formed from the fact, that nearly 500,000 barrels of herrings only have been cured in one year; of which more than half were exported. The number of persons to whom this Fishery gives employment in various ways, must, therefore, be very considerable, though it cannot be exactly estimated; and the value of the product as an article of export trade is very important. The total number of persons *directly* employed in the Cod and Herring fisheries of Britain, as Fishermen, Coopers, Curers, &c., was nearly 87,000 in the year 1836. Of the extent of the Pilchard fishery some idea may be formed from the fact, that about 12,000,000 of these fish have been sold for home consumption alone in a single year; and it is said that more than this number have been brought into one port in a single day. The principal centre of the Herring fishery is at Yarmouth in Norfolk; that of the Pilchard fishery is the neighbourhood of the Land's End.

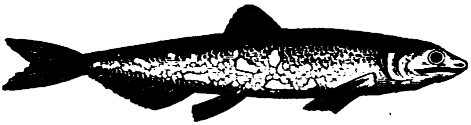


FIG. 276.—ANCHOVY.

572. With the preceding order is arranged by Cuvier the *Lepidosteus* or *Bony Pike*, which has many of the characters of the Pike, with the structure of the head of the Herring. It differs from both these, however, in having the body covered with a case composed of dense bony square scales; which are so fitted together as to form a most complete armour. An in-

creased knowledge of its internal structure, however, and of the fossil species most nearly allied to it (which are very numerous in the older rocks), has led to a very different position being assigned to it. Its skeleton differs in many particulars from that of ordinary Fishes, and presents several points of resemblance to Reptiles; and this approximation is equally remarkable in the structure of the respiratory apparatus,—the air-bladder being double, and communicating with the œsophagus by a regular trachea or wind-pipe, furnished with a glottis at its upper extremity, so as to be nearly as complete as the lungs of the Siren. In regard to the order of *Sauroid* fishes, of which this is nearly the only genus at present remaining, but which was once the predominant group of Fishes, more will be said hereafter (§ 582). The Lepidosteus is an inhabitant of the rivers and lakes of America, most of the species being restricted to its warmer parts.

ORDER III.—MALACOPTERYGII SUB-BRACHIATI.

573. The Fishes of this order, from the position of their fins, have greater facility of ascending and descending, than the abdominal fishes; and the range of depth inhabited by the same animal is consequently greater,—except where, as in the Flat-fish, there is a peculiar adaptation to a residence at the bottom of the sea. The first family is that of the GADIDÆ, or the *Cod* tribe; which have a long body, rather slender, and covered with soft scales,—the head, however, being naked. They live for the most part in the seas of cold or temperate climates; and from their size and their tendency to congregate in particular localities, as well as from the wholesomeness and good flavour of their flesh, they are probably more important to Man than any other family of Fish. The Cod fishery on the banks of Newfoundland sends a vast supply to almost every part of the world; and the amount caught on the British shores also is very considerable. The appearance and quality of the fish vary considerably according to the nature of the ground on which it is taken. Its repro-

ductive powers are enormous; the roe of a single female having been estimated to contain nine millions of eggs. Nearly allied to the Cod, are the *Haddock*, *Whiting*, *Hake*, *Ling*, *Rockling*, *Coal-fish*, and others. The first of these is considered as the most delicate of the whole family, when fresh; but it does not take salt well; and for preservation, the Cod and Ling excel the rest.

574. The second family of this order consists of the PLEURONECTIDÆ, or *Flat-fish*. These present several remarkable peculiarities of structure; by which they are distinguished, not only from all other Fishes, but even from all other Vertebrated animals. Their body is extremely compressed, or flattened at the *sides*; the animal, however, does not habitually swim with these sides erect in the water, but usually lies flat on the bottom, one side being in contact with it, and the other being directed upwards. The lower side is generally white, whilst the upper is brown; and the former is commonly (but erroneously) regarded as the belly of the fish, and the latter as its back. The dark colour of the upper surface harmonises with that of the bed on which the fish lie; so as to enable them to conceal themselves from their foes, or to watch for their prey, without being themselves observed. Individuals are occasionally met with, in which both sides are coloured alike; these are said to be "Doubles." It is usually the coloured side which is doubled; though it is occasionally the white one. By a change in the position of the head, both the eyes are brought round to the light side, so as to look upwards, when the fish is lying on the bottom; this change may be designated as a sort of twisting-round; but it also involves an unequal development of the bones on the two sides of the head, which shows itself in the mouth. Of the pectoral fins, too, one is usually larger than the other. The dorsal fin is continued along the whole of the ridge of the back, from the head to the tail; and the anal fin usually forms a like continuous expansion below, sometimes uniting with the ventral fins. These fishes have no air-bladder, and they seem to have little power of rising from the bottom. When disturbed, they will raise themselves into a vertical position, so as to show their white sides; and

they then dart along with great rapidity; but they soon return to their usual posture, and glide along with a sort of undulating motion, at a little distance from the bottom. The Flat-fishes are very tenacious of life; and the flesh of all of them is very palatable. That of the Turbot is considered as the most delicate afforded by any marine fish. Although most of the species are exclusively marine, yet the Flounder and some others occasionally ascend rivers, and thrive in brackish, or even in quite fresh water. The *Plaice*, *Flounder*, *Turbot*, *Dab*, *Fluke*, *Brill*, *Sole*, and other well known fish of this family, are closely allied to each other, both in structure and habits; and they are all inhabitants of British seas. The *Halibut*, also an inhabitant of the Northern seas, is larger than any one of these, attaining a length of six or seven feet, and a weight of 300 or 400 lbs. Its flesh is rather coarse and dry, but it admits of being salted. In some of the Mediterranean species, the eyes look towards the left side, instead of towards the right; the latter, though the ordinary rule of the family, is sometimes departed from in other species; the individuals that exhibit the unusual formation, being said to be "reversed." As an instance of the extent and importance of the Fisheries, of which this family is the object, it may be mentioned that the Dutch draw about 80,000*l.* per annum, for the supply of Turbot alone to the London market; and it is estimated that, of the whole quantity brought to Billingsgate, the Dutch is not more than one-fourth.

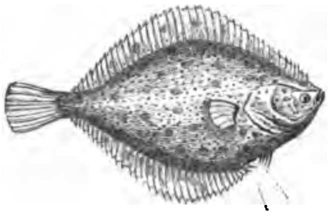


FIG. 277.—PLAICE.

575. The third and last family of the second division of Soft-rayed fishes, is but a small one; and consists of a group which is characterised by the union of the ventral fins into a sort of sucker, or disc, that enables them to form a strong adhesion to rocks and other hard substances. In this manner they can remain and find their food, in situations where every other

species of fish would be swept away by the current. From this curious conformation, they have received the name of DISCOBOLI. Their skin is slimy and naked, or with hard grains imbedded in it. Their pectoral fins are large; and they swim with great vivacity in shallow water, and near coasts. Several species of this family, most of them small, are found on the south and west coasts of England. One of the largest is known as the *Lump-fish;* this is found as far northwards as the margin of the Polar ice, and is a palatable article of food; its name is derived from the clumsiness of its form, its height being about half its length, and its thickness about half its height. The *Remora*, or *Sucking-fish*, (§ 529), is placed by Cuvier in this family, although its disc, or sucker, is so entirely different in its position; but he remarks, that it might be placed by itself, as the type of a distinct family.

ORDER IV.—MALACOPTERYGII APODA.

576. The fishes in which the ventral fins are always wanting, form but a single natural family; MURÆNIDÆ, or the *Eel* tribe. These are at once known by their long, slender, snake-like bodies, covered with a soft skin, and having the scales very minute, and often almost invisible. The gill-orifices are very small, and are prolonged far back, so that a sort of long passage is formed from the branchial chamber to the surface of the body. In this manner the gills are so much sheltered, that the fish can remain out of the water for a considerable time, without those organs being rendered unfit (by becoming dry), to carry on the respiration. Of course, the access of water to the gills cannot at any time be so free, as it is in fishes with large gill-openings; and their respiration may be habitually less. It is in animals with a feeble respiration, as has been already remarked in the case of Reptiles, that we find the greatest tenacity of life; and every one knows the difficulty with which the Eel is killed—the most cruel injuries being sustained by it without the loss of its vitality. The ordinary Eels, of which there are several species,

inhabit ponds, rivers, and the brackish water at the mouths of rivers. In the autumn they make their way to the sea in vast numbers; for the purpose, it is believed, of depositing their spawn. Myriads of minute Eels, three or four inches long, are seen in the spring, making their way up rivers, and dispersing into the tributary streams as they proceed; but whether the parent Eels thus return is uncertain. It is well known that the Eels which inhabit inland lakes and ponds, whence they cannot escape to the sea, are able to breed without this migration; but it appears that their season is somewhat later, the water in such situations being colder than that of the sea in the early spring. Eels frequently quit the water, in warm, damp nights, and wander over the grass; either in quest of worms, frogs, or other food; or in order to change their locality.—Many of this family are chiefly marine; though they occasionally stray into the mouths of rivers: this is the case, for instance, with the *Conger*, which is one of the largest of the whole order, sometimes measuring six feet in length, and being as thick as a man's leg.—The *Ophisurus*, or *Snake Eel* (so called from its strong resemblance to a serpent) of the Mediterranean, attains the same length, but is not so thick. In the genus *Muræna*, and its allies, the pectoral as well as the ventral fins are wanting; and the gill-openings are extremely small. This, too, is a Mediterranean fish; it was much esteemed by the ancients, who kept it carefully in ponds; and there is a well-known story of a cruel master, who caused his offending slaves to be flung alive into the ponds, to feed the Murænæ. The common species grows to the length of three feet or more; its surface is mottled brown and yellow; and it is very voracious and ugly. In some of the genera nearly allied to this, the gill-passages unite, so as to open externally by a single orifice on the under side of the neck; and in several of these, we find the air-bladder almost as completely presenting the characters of a rudimentary lung, as in the Sauroid Fishes (§ 588).

577. The *Gymnoti*, or *Electric Eels* (§ 540), and their allies, have been separated from the preceding family by some naturalists, on account of the less complete inclosure of the gill-covers

by the skin, and of the absence of the dorsal fin (Fig. 262). It is to the true Gymnotus, that the electric power is confined; and the group includes several other genera, of which some belong to the British seas. Of these may be mentioned the *Leptocephalus*, or *Morris*, which is a small riband-shaped fish, with a body so thin and transparent that its internal structure can be seen without dissection; it lurks among sea-weeds, and is very lively in its motions. The *Amnodytes*, or *Launces*,—one of which is known to fishermen by the name of the Sand-Eel, and another as the Sand-Launce,—are remarkable for their habit of burrowing in the sand, in which they find the worms that constitute their chief food. They become in their turn the prey of the Salmon; to whose support, whilst they are in the estuaries of rivers, the Launces are believed to contribute largely.

ORDER V.—LOPHOBRANCHII.

578. This order consists of a small group, which is separated from all other Osseous Fishes by the structure of the gills; which, instead of hanging from the branchial arches in fringes of parallel fibres, disposed like the teeth of a comb, are set upon them in small round tufts, arranged in pairs. From this peculiar conformation, the name of the order, which signifies *tuft-gilled*, is derived. The gills are defended by a large operculum, which is attached by a membranous covering on all sides, except at one part where a small hole is left for the escape of the water. These fishes are also distinguished by having their body covered with shields or small plates, which often give it an angular form. In general they are of small size, and often without flesh. They do not present many points of general interest; but there are certain peculiarities in their organisation, which are very interesting to the Naturalist. In the *Syngnathus*, or *Pipe-fish*, which has a prolonged muzzle like that of the Fistularidæ (§ 566), the eggs are not deposited as in other Fishes, but are conveyed into a sort of pouch, formed by a doubling of the skin under the body of the male; this pouch is under the abdomen in some

species, and at the base of the tail in others. In this pouch the eggs become matured; and when the fry are ready to escape, it opens and allows them to pass out. This contrivance reminds us of the pouch of the Marsupial Mammalia; but there is this striking difference, that in the latter it is the Female which affords this protection to the young, whilst in the Pipe-fishes it is the Male. It has been asserted that, even after the young have quitted the pouch, they will return to it again; and that the parent shows great attachment to them. The *Hippocampus* (Fig. 259) has a prehensile tail, unfurnished with any finny expansion; and is enabled by its means to climb or hold on by the stalks of marine plants. It is only in the dead specimen, that the neck acquires the peculiar bend, which gives its head the resemblance to that of a Horse, from which its name is derived. The *Pegasus*, though furnished with a snout, has the mouth beneath it; the pectoral fins are large, and are spread out in a wing-like manner; whence these curious Fishes have derived their name, which signifies Flying Horses.

ORDER VI.—PLECTOGNATHI.

579. We next come to another small order, which forms a connecting link between the Osseous and Cartilaginous fishes. It resembles the latter, in having the upper jaw attached to the cranium, in such a manner as to possess but little power of motion (whence is derived the name of the Order, which means having the jaws soldered), and also in the imperfect ossification of the skeleton. Still, in its general conformation, the skeleton rather resembles that of the bony fishes. The gill-lid is concealed under the thick skin, as in the preceding Orders; and there is but a small gill-opening on either side: the ribs are scarcely developed. This Order includes two families, which are distinguished by the structure of their teeth. In the first of these, the *Gymnodontes*, or Fishes with naked teeth, the jaws are shaped like the beak of a Parrot; and are composed of parallel plates of a substance resembling ivory. These are reproduced as

fast as they are destroyed by wear; and they constitute very efficient instruments for grinding down the food on which these animals live,—which consists of Crustacea and sea-weeds. To this family belong the *Globe-fishes;* which are so named from their power of distending themselves into a spherical form, by inflating with air a large sac contained in the abdomen. When thus distended, they float along the water with the back downwards, swimming onwards by means of their pectoral fins; and they are covered with a series of large spines, which are raised up when the body is thus inflated, so as to form a very efficient means of defence. From this last circumstance, these Fishes have been sometimes termed Porcupine-fish. There are three genera in which this curious power exists; the *Diodon* (two-toothed), in which there is no furrow or division in the jaws, so that each seems like a single tooth;—the *Triodon* (three-toothed), in which there is a division in the centre of the upper jaw; so as to divide it, as it were, into two teeth;—and the *Tetrodon* (four-toothed), in which there is a division of this kind in each jaw. Besides these, this family contains the *Orthagoriscus*, or *Sun-fish* (so named from its rounded form), which looks like the anterior half of a fish cut in two in the middle. It has the power of floating with its head and eyes above water; but not of distending itself with air; in this state it moves along sideways, very slowly, however; and appears like a dead or dying fish. The Sun-fish (or Moon-fish, as it is sometimes called) attains a considerable size; of the short species, which is most remarkable for its peculiarity of form, individuals have been frequently caught measuring four feet in length, and nearly as much in breadth, and weighing 400 lbs.; and it has been stated occasionally to attain double that weight.

580. In the second family, that of BALISTIDÆ, or *File-fishes*, the jaws are armed with a small number of distinct teeth; the skin is either rough, or covered with very hard scales,—whence their name, and the mouth is prolonged into a sort of pyramid. In their general form, and in the brilliancy of their colours, they bear a considerable resemblance to the Chætodons (§ 556); and, like them, they inhabit the seas of warm regions, keeping near

the surface, or in the neighbourhood of rocks. Some of them are remarkable for the appendages with which the body is furnished, which are especially striking in the *Balistes pencilligerus*; their use, however, is entirely unknown.—The *Ostracions, or Trunk-fishes*, should probably be placed in a distinct family, so remarkably are they distinguished by the mode in whch the body is protected. The head and body are covered with plates of bone, soldered together in such a manner as to form an inflexible cuirass; leaving only the tail, the fins, the mouth, and a small margin of the gill-opening, capable of motion,—all of which moveable parts pass through openings of the cuirass. The greater part of the vertebræ also are soldered together. There are no ventral fins, and the dorsal and anal are small and are placed far back; there is little flesh; but the liver is large, and abounds in oil. The surface is often armed with spines. No species of these singular Fish are known in the British seas.

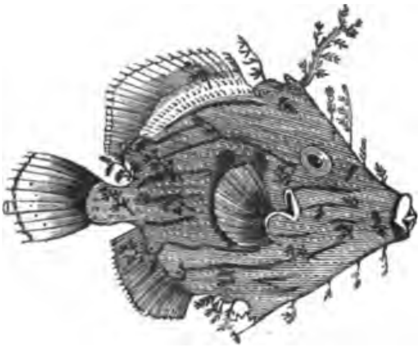


Fig. 278.—Balistes Pencilligerus.

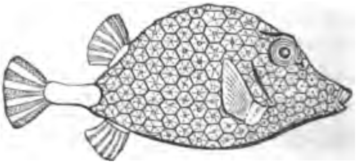


Fig. 279.—Trunk-Fish.

ORDER VII.—CHONDROPTERYGII BRANCHIIS LIBERIS.

581. We are now arrived at the true Cartilaginous fishes (§ 525); of which the first order so far resembles the Osseous group, that the gills are connected externally with a single wide opening on each side, furnished with an operculum, or gill-cover. All the Fishes of this order are considered by Cuvier as belonging to a single family; but they may be probably better arranged under two families, the ACIPENSERIDÆ, or *Sturgeons*, and the CHIMÆRIDÆ, or *Chimæras*,—the former having more affinity to the Osseous fishes, and the latter to the Sharks. The body of the *Sturgeon* is more or less covered with bony plates, arranged in longitudinal rows; and the head is armed with the same. The mouth is situated beneath the elongated muzzle, and is small and toothless. The air-bladder is very large, and communicates by a wide opening with the gullet; and in this, and other points of their internal conformation, the Sturgeons show a considerable approach to the Lizards, whence they are ranked among the *Sauroid* fishes (§ 588). The form of the tail is another mark of resemblance; for the vertebral column is continued into the upper portion of the caudal fin, the lower one being given off from its underside,—instead of stopping short at its commencement, and sending off the upper and lower portions of the fin in the same manner, as in nearly all other Fishes (Fig. 246). Sturgeons, like Salmon, ascend large rivers for the purpose of spawning; and they are the subject of valuable fisheries. They are more abundant in the Continental rivers than in those of Britain; and are particularly numerous in those

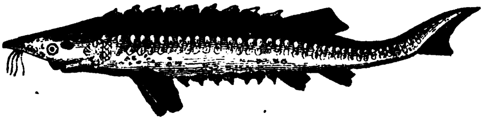


FIG. 280.—STURGEON.

which fall into the Black and Caspian seas. The common Sturgeon attains the length of six feet; but the great Sturgeon has been found twelve or even fifteen feet in length, and weighing from 1200 to 3000 lbs. The flesh of the former is very palatable and wholesome, resembling veal in its character; that of the latter, however, is not esteemed. The *Sterlet* is a smaller species, about two feet long; which is found in the Russian rivers, and is considered a great delicacy. All the species are valued on account of the excellent Isinglass which is yielded by their air-bladders; and their roe is salted and prepared by the Russians, forming a dish termed *caviare*. More than 400,000 lbs. of this have been prepared in the Caspian fishery, in a single year.—The Chimæridæ have the gills not entirely free at their extremities, but partly attached, as in the Sharks; and although there is externally but a single gill-opening, yet internally there are five separate passages, terminating in the common aperture. They lay large, flattened, eggs, included in a sort of leathery covering; in which respect, also, they resemble the Sharks. The commonest species is known under the name of the "King of the Herrings."

Order VIII.—CHONDROPTERYGII BRANCHIIS FIXIS.

582. This order includes the two families of Sharks and Rays; which, though very different in external form, agree in many points of internal structure, and particularly in having the gills fixed at their extremities to the outer sides of the gill-cavity, and in having a series of apertures, through which the water passes out from each branchial arch. In these particulars they correspond with the last order of the class,—that of Cyclostome Fishes; but they differ from them in having a much more perfect skeleton, and in having both pectoral and ventral fins. The differences between the two families of Squalidæ, or the *Shark* tribe, and Raidæ, or the *Ray* tribe, chiefly consist in their external form; the body in the former being elongated, and the

tail extremely fleshy; whilst in the latter the body is short and flat, the pectoral fins immensely extended, and the tail slender. Of the true *Sharks*, there are several species, of which the *White-shark* is the most notorious. It sometimes attains the length of twenty feet, and its mouth is sufficiently wide to enable it to receive the thigh or even the body of a Man. This species inhabits most of the seas of warm latitudes; but it is rarely or never seen near our own shores. The *Fox-shark*, or *Thresher*, is remarkable for the great development of the upper lobe of the caudal fin, into which the vertebral column is prolonged (§ 581); this being nearly as long as the entire body. This fish is occasionally met with on our own coasts, and sometimes attains the entire

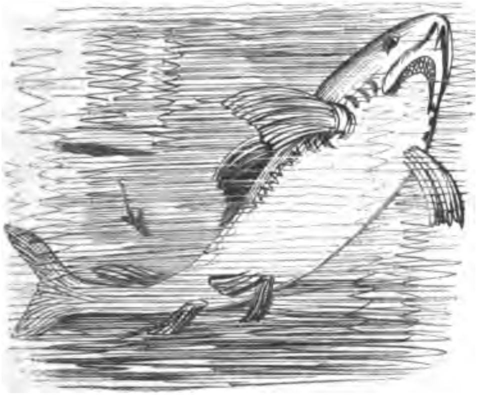


FIG. 281.—WHITE SHARK.

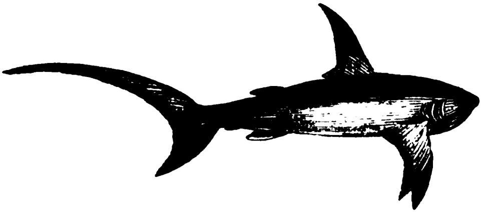
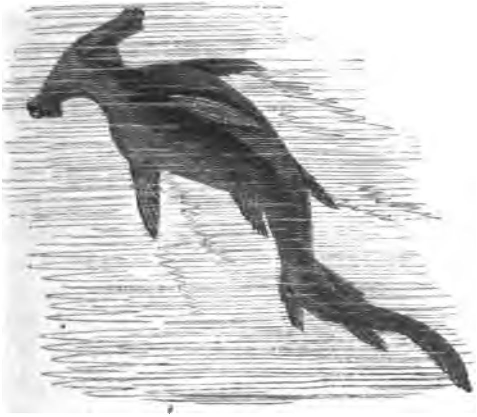


FIG. 282.—FOX-SHARK.

length of from ten to twelve feet. Its gape is not so wide, nor are its teeth so formidable in proportion to its size, as those of the preceding; but its tail is a powerful weapon, and it is exceedingly bold and voracious in its disposition. It has been stated on good authority, that it is not uncommon for a Thresher to approach a herd of Dolphins which may be sporting in unsuspicious security, and by one splash of its tail to put them all to flight, like so many hares before a hound; yet the Dolphin is six times the bulk of the Thresher.—The *Blue-shark* bears more resemblance to the White in its general form, but is much smaller, not exceeding six or seven feet in length. It is very common off the Cornish coast, and is extremely troublesome to the fishermen during the Pilchard-fishing season, cutting their lines and nets, and devouring the fish.—The *Porbeagle* belongs to an allied genus, *Lamna*, which differs from the true Sharks in having a pyramidal snout, and the gill-openings placed rather further forwards. Its common name seems to be compounded of Porpoise and Beagle; for it bears some resemblance to the former in shape, whilst it corresponds with the latter in its habit of hunting in packs. It is occasionally met with on almost all parts of the British coasts, being found chiefly in currents near rocky places; it is voracious in its habits, swallowing entire Fishes of two feet in length.—The *Notidamus*, which is an inhabitant of the Mediterranean, is the largest of the true Fishes, its length being sometimes as much as thirty-six feet; but it is comparatively harmless.

583. This family contains many other genera, more or less departing from the ordinary type; among these we may mention the curious *Zygœna* or *Hammer-headed Shark;* which resembles the ordinary Sharks in the form of its body, but has its snout prolonged into the form of a double-headed hammer, with an eye in the middle of each extremity. It is occasionally met with in European seas, attaining the length of twelve feet, and larger ones are said to inhabit the tropical ocean.—The *Dog-fish* is nearly allied to the Sharks; and is probably more abundant on our own coast than any other of the order. Almost every one who walks along the shore may meet with its

eggs, which are enclosed in flat oblong cases, with a long tendril from each corner, by which it clings to solid bodies, or to sea-weed. In these cases, which are commonly known by the name of "fairies' purses," there is a fissure at each end, which admits the free access of sea-water to the egg; and through one of these the young subsequently escapes. The Small Spotted Dog-fish is the species most common on our own shores; and it is not only very troublesome to the fishermen by entangling itself in their nets, but also by frightening away the shoals of Herrings, &c., which are migrating towards the coast.—The last fish of this family here to be noticed, is the *Pristis* or *Saw-fish;* so named from the extension of its snout into a long flat blade, furnished with a row of sharp spines, resembling teeth, on either side. With this formidable weapon the Saw-fish attacks the largest Whales, and inflicts very severe wounds. It sometimes attains



283.—HAMMER-HEADED SHARK.

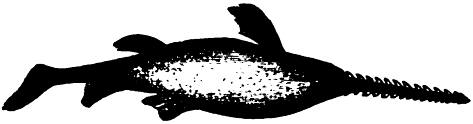


FIG. 284.—SAW-FISH.

the length of twelve or even fifteen feet. This fish is very widely distributed, being found in the arctic, antarctic, and tropical seas; but it seldom approaches the shore.

584. The true *Rays*, typical of the family RAIDÆ, have the body so flattened, that the pectoral fins seem like a continuation of it; and these meet in front of the snout, and are prolonged backwards as far as the ventral fins; thus giving to the whole body a nearly circular form. The eyes are situated on the upper side of the body, as in the Flat-fish (§ 564); but it will be observed, that the plan of construction of the Rays and Skates, is entirely different from theirs, the two margins being here composed of the edges of the pectoral fins, whilst in the Flat-fish they are formed by the dorsal and anal; and the Flat-fish habitually lying on one side, whilst the Rays, &c., lie on the abdominal surface, where we find their mouth and gill-openings. These fish live for the most part near the bottom of the water, on beds of sand or mud. When disturbed, they glide along in an undulating manner, with a slight motion of the pectoral fins; and if attacked, they defend themselves by lashing violently with the tail, which is often furnished with sharp spines. In the *Sting-Ray* (*Trygon*), the tail has a single strong spine, notched on both sides. There are several species, intermediate in form between the Sharks and Rays, by which the two families are connected. Most of the family are extremely voracious, feeding on Fishes and Crustacea, and on naked or testaceous Mollusks. The teeth are flattened and lozenge-shaped; and so powerful are the jaws, that they are capable of crushing the shell of a Crab with the greatest ease. Some of the Rays produce their young alive; in those which lay eggs, these are deposited in a horny case, like that of the Dog-fish. One of the most common of the British species is the *Thornback;* so named from the skin of its back being covered with thorny tubercles, variable in their number; this fish is taken in abundance in the spring and summer, when it visits the shallows for the deposition of its

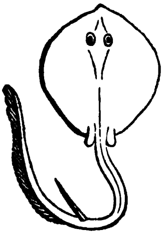


FIG. 285.—STING-RAY.

eggs, and it is an excellent article of food. The *Torpedo*, or *Electric Ray* (§ 542), is occasionally met with on the Channel-coast of England; but it is more common in warmer seas, especially the Mediterranean. It is peculiar, not only from the possession of the electric apparatus, but also on account of the fiddle-shaped form of its body (Fig. 263). The *Myliobates* receives its common name of *Sea-eagle*, from having the pectoral fins of extreme breadth, so that it much resembles a bird of prey, with its wings expanded. It inhabits the depths of the ocean, and attains a very large size; in a specimen caught in the West Indian seas, the length of the body was 10 feet, its greatest breadth 13 feet, and the length of the tail 15 feet.

ORDER IX.—CYCLOSTOMATA.

585. The Fishes of this Order are the least perfect of the whole class, in regard to the construction of their skeleton; and are, therefore, at the bottom of the whole series of Vertebrated animals; which they may be correctly regarded as connecting with the Invertebrated sub-kingdoms. So far are they from having a jointed vertebral column, that this is replaced, in the highest among them, by a sort of cylinder of cartilage, which represents the bodies of the vertebræ, but which does not show any definite division into segments; and in the lowest, this cylinder has not even the firmness of cartilage, but consists of a membranous bag, containing a gelatinous semi-fluid substance. There are no ribs, nor are there either pectoral or ventral fins; there is, in some, however, a kind of fin beneath the tail, but this has no rays. The body is usually prolonged, and nearly cylindrical; and terminated by a circular mouth adapted for sucking. In the *Lampreys* there are seven gill-openings on each side; there are strong teeth in the ring formed by the pair of jaws; and the inner part of the disc, which may be considered as the lip, is also beset with hard tooth-like tubercles. The tongue, which moves backwards and forwards like a piston, and which is the principal instrument in the act of suction, is also furnished

with two longitudinal rows of small teeth. By means of this sucker, the Lamprey can attach itself to the bodies of the largest fishes; and is able speedily to pierce through their integuments, and to prey upon their substance. The largest species, which attain the length of two or three feet, are marine; the former, which chiefly inhabit rivers, are sometimes called Lamperns. The members of the genus *Myxine*, or *Hag*, and its allies, have not even a cartilaginous ring around the mouth, its borders being entirely membranous, and furnished with only one tooth. The mouth is surrounded by eight cirrhi, or tendril-like feelers; which remind us of the arms of the Cuttle-fish in miniature. This fish is destitute of eyes; and does not seem, indeed, to have any other special organ of sensation than these cirrhi. The best known species is known to British fishermen under the name of the *Hag;* it is found in the interior of other fishes, whose bodies it has entered for the purpose of devouring them; and it seems to attack in preference those which have been hooked, and which, consequently, are not able to defend themselves. As many as six Hags have been found in the skin of a single Haddock, on the Norway coast (where this species is more abundant than our own), the flesh of which they had almost entirely consumed. It is usually from twelve to fifteen inches in length, and of the thickness of the little finger; and its whole tissues are so soft, that it would not have been supposed capable of inflicting any serious injury. The quantity of mucus which it can secrete from its surface is enormous; it has been asserted, that if a Hag be placed in a pitcher of sea-water, it will speedily convert this into a semi-transparent jelly; and that, if placed in a fresh quantity of water, it will change this in the same manner. The most imperfectly formed of all Fish is, probably, the *Amphioxus*, or *Lancelot;* which has, by many Natu-

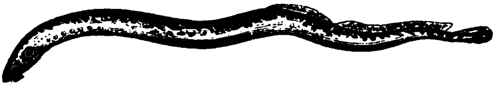


FIG. 286.—LAMPREY.

ralists, been removed altogether from the Vertebrated sub-kingdom, on account of the almost complete absence of what are usually regarded as the distinguishing peculiarities of that group. Nevertheless, an attentive examination of its structure shows, that it bears a closer resemblance to the true Fishes than to any other animals—exhibiting their conformation in (as it were) a degraded form. It is of very diminutive size, scarcely an inch in length, very slender, and almost transparent. The body is compressed laterally; and there are no pectoral, ventral, anal, or caudal fins, but only a single dorsal fin, extending the whole length of the body. There are no eyes, nor any vestige of any external organ, except a mouth, which is surrounded by small tentacula, like that of the Hag. There is scarcely any trace of a vertebral column, or of ribs; yet the muscles are arranged with great regularity, on the plan of those of Fishes in general. One of the most curious parts of its structure is the complete absence of cerebral hemispheres, and even of ganglia of special sense; the spinal cord being, apparently, the only centre of its nervous system. Thus it may be characterised as one of those "experiments prepared for us by Nature;" exhibiting to us a case, in which the Cerebrum is never developed; the phenomena of which closely correspond with the results that have been obtained by the artificial removal of that organ. (ANIM. PHYSIOL. § 465.)

586. The Geological distribution of this class presents many points of the greatest interest to the Zoologist. As might have been anticipated from what is known of the history of the production of the present crust of the globe, we find remains of Fishes in the very earliest formations which distinctly exhibit the action of water, —that is, which were deposited as sediments in the bed of the ocean; and this long before we have reason to believe that any land animals existed upon the surface of the globe. But the Fishes of this early date were, for the most part, formed upon a very different plan from those of the present epoch, so that there are very few of those now existing, which bear any close resemblance to them; whilst, on the other hand, the greater proportion of

the species now existing had no representatives among those, which inhabited the primeval ocean. Many of the latter are known to us only by their scaly coverings, which are frequently preserved with the greatest perfection, when the internal skeleton has disappeared,—the scales having the hardness of bone or even of enamel, whilst the skeleton was cartilaginous.—As we ascend towards the newer formations, which are nearer the surface of the earth, we find the character of the class gradually changing,—the forms, which were predominant in the older rocks, disappearing one after another, and being replaced by others, which bear more resemblance to those now existing. It has been discovered by Professor Agassiz, who has devoted a large part of his life to the study of Fossil Fish, that there is a constant correspondence between the character of the scales and the internal organisation of the fish; and he has proposed that the arrangement of the class shall be founded in the first instance upon the form and structure of the Scales. This classification has not yet been received amongst Naturalists, as superseding that of Cuvier; but the advantages which it presents, in regard to the study of Fossil Fishes, give it a claim to our attention. —According to Professor Agassiz, all Fishes may be arranged under the four following groups:

I. GANOIDIANS; from the Greek γανος, *splendour.*—The Fishes of this order are covered by angular scales, composed internally of bone, and coated with enamel. The scales are *regularly* arranged, and entirely cover the skin with an almost impenetrable armour.—This order includes the *Sauroid* fish (§ 588), of which the Sturgeons and the Lepidosteus are the only existing representatives; together with many other peculiar forms, to which we have nothing at all analogous among the Fishes now existing.

II. PLACOIDIANS; from the Greek πλαξ, *a broad plate.*—This order contains Fish whose skin is covered *irregularly* with plates of enamel, often of considerable dimensions, but sometimes reduced to small points, like the shagreen on the skin of the Shark, and the prickly tubercles of the Ray.—Among existing fish, this order comprehends only the Sharks and Rays and their allies; but these form but a very insignificant part of the species which are to be referred to it.

The two preceding Orders are further characterised by the peculiarity in the form of the tail, which has been pointed out in the Sturgeons (§ 581); and which, among the existing fishes, is confined to that family, with the Sharks and Rays, and the Lepidosteus.

III. Ctenoidians; from the Greek κτεις, genitive κτενος, *a comb.* The Ctenoid fish are covered with horny or bony scales, jagged like the teeth of a comb on the outer edge. The *Perch* and many other existing genera are examples of this order, which contains but few fossil forms.

IV. Cycloidians; from the Greek κυκλος, *a circle.*—The Fish of this last order have their scales smooth and simple at the margin, and often ornamented at the upper surface. The *Herring*, *Salmon*, &c., are referred to the Cycloid order; which, with the preceding, includes all the existing species, with the exception of the few that have been already mentioned as belonging to the preceding groups.

587. Now the Fish of the oldest or Palæozoic strata belong almost exclusively to the *first* of these divisions; and of eighty species of Ganoid fish,—which are all that have been hitherto described,—upwards of fifty are exclusively met with in the Old Red Sandstone formation alone. Many of the forms presented by these are most extraordinary,—being totally unlike any with which we are acquainted among existing species,—and indicating an obvious mixture or combination of the characters of the class of Fish with those of the Crustacea. Indeed in regard to the real nature of some of the species discovered a few years since in Scotland, even Agassiz was at first undecided,—so strong was the resemblance presented by them to certain forms of Crustacea, especially the *Trilobites* hereafter to be described (§ 764); and it was not until connecting links were discovered, in which the distinctive characters of the true Fish were more obvious, that the nature of the first could be certainly determined. The head and body of many of these fish were covered by large hard plates; whilst the internal skeleton, from the

entire absence of any remains of it, seems to have been composed of soft cartilage. In the *Cephalapsis* (or buckler-head), the head was very large in proportion to the body, occupying one-third of its length, and being rendered of enormous breadth by two crescent-shaped wings, extending backwards and outwards. In the *Pterichthys* (or winged fish), the plates both of the head and body were very large, and consequently few in number; it was furnished with a pair of wing-like fins, placed far forwards, and terminating in a kind of hook, or strong curved point; and the tail, which occupied more than a third of the total length of the animal, was straight, pointed, and covered with small tuberculated angular scales. "Most probably the tail was employed as the principal organ of locomotion; the pointed fins being elevated at the approach of danger, and the animal in this way rendering itself as unapproachable and as difficult to be swallowed as its form would admit of." The *Cocosteus* had a body of triangular shape, tapering away towards the tail; and was covered almost entirely by a central plate, much larger than any of the others, having a continuous ridge along the middle of the back; it was also furnished with a couple of defensive fins, situated near the head, like those of the Pterichthys. The tail evidently possessed a vertebrated structure; and it was by this that the animal was most certainly recognised as a Fish,—its jaws and teeth having more the characters of the nippers of a Lobster or the mandibles of a Beetle. The teeth were chiselled, as it were, out of the solid bone of the jaw; just as the teeth of a saw are cut out of a plate of steel: and the line of opening of the jaws was *vertical*, as in the Articulata, instead of being *horizontal*, as in the Vertebrata. Remains of this fish are found very abundantly in some situations; varying from a few inches to two feet in length.—The other Fishes of the Palæozoic epoch were, for the most part, less widely different from those of the present day; one remarkable genus may be mentioned, the *Holoptychius*, which exceeded most of the others in size, and was evidently adapted to prey upon them. The name of this fish is derived from the large undulating furrows marked upon the surface of its enamelled scales, which give them a most beautiful appearance; these scales, by their strength and magnitude, seem as if they might have served for the armour of a Crocodile ten times the size of the fish. Its head, also, was inclosed within bony plates, whose upper surface was covered with rough tubercles of enamel; and the jaws, likewise, were composed of bone, whose outer surface was polished, covered with enamel, and unclothed with skin. A row of thickly-set pointed teeth fringed the enamelled edges of the mouth, and corresponded to the lips of ordinary fish; whilst within this was a second and wider range of teeth, at least twenty times the bulk of the others. This, and some other allied genera, were evidently the "pirates" of their day; the extraordinary armature of their jaws being in conformity with the remarkable defences, with which the bodies of the fishes that served for their prey were endowed.

588. As we pass from the Old Red Sandstone into the newer rocks, we meet with a change in the characters of the Fish, whose remains are imbedded in them. All those just described, with the exception of the last, disappear; and they are replaced by others. Still we find that of the Fish contained in the Mountain Limestone and the beds associated with it, a large proportion belonged to the order Ganoidians; but, among these, the *Sauroid* fishes now predominate. These are at once distinguished by the peculiar form of their teeth; which are marked by longitudinal furrows like those of Crocodiles; and which have a conical hollow at the base, in which the next tooth is prepared, as in many Reptiles. So strong, indeed, is the resemblance of both the teeth and scales of several of the Fishes of this group to those of some Crocodilian animals, that, when first discovered, they were immediately referred to that class. The dimensions of the teeth of the genus *Megalicthys* (large fish), far exceed those of any other fishes' teeth that have been yet examined; one of them having been found to measure nearly four inches in length, with a breadth at the base of nearly two inches. The large teeth are accompanied by several very small ones, which alternated with them, and were distributed over the whole of the inside of the mouth. Scales of this fish have been met with as much as five inches in diameter.

There is some reason to think, from the character of the other fossils with which its remains are associated, that this Fish was an inhabitant of fresh water, like the comparatively diminutive Lepidosteus of the present day (§ 572). The Sauroid fishes predominate in an increasing degree among the genera of the Ganoid order, as we rise through the newer strata; and at last they become the only representatives of that order. It is between the Oolitic and Chalk periods, that we find the most remarkable change in the proportion which the Fishes of this group bear to those of other orders; for, whilst the Oolite includes the remains of numerous fishes of the Ganoid order,—many of them Sauroid fishes of great size and strength,—we find but very few in the Chalk and later formations, and even these are of diminished size and ferocity; so that, by this gradual change, the order has now become nearly extinct, as already mentioned.

589. It is in the strata of the Carboniferous order, or the Mountain Limestone and the overlying beds of the Coal series, that we encounter the first appearance, in any considerable proportion, of the Fishes of the Second order, or *Placoidians.* These do not depart so widely from the forms with which we are familiar at the present day, as did the earlier Ganoidian Fishes; but it is interesting to remark, that the greater number of the early Placoidians did not bear a resemblance to the Sharks and Rays which are most abundant at the present time, but to some that are now regarded as aberrant forms, separated from the rest by peculiarities of conformation. This is the case, for example, with the *Cestracion Philippi*, or *Port-Jackson Shark;* which has the margins and inner surface of the jaws covered with flat pavement-like teeth, disposed in an oblique row; whilst the front of the mouth is armed with sharp, angular, and pointed teeth, more resembling those of the ordinary Sharks. The latter are evidently adapted for seizing and retaining the food; the former for crushing and bruising it. These teeth are rarely found connected together in a fossil state. Now, of the fossil Fishes presenting these peculiarities, and referred on that account to the family *Cestracionts*, remains are found even in the

Palæozoic strata; they become more numerous in the Carboniferous series; they are very numerous in the Lias and Chalk formations; but there they cease almost entirely,—the strata of the Tertiary series scarcely containing any of them, and the Port-Jackson Shark being the only representative of this family at the present day.—Intermediate between these and the ordinary Sharks was another family, to which the name of *Hybodonts* has been given. The teeth of this division were stronger and blunter than those of the true Sharks, but were not so much flattened as those of the Cestracionts; and they seem to have been adapted for cutting, tearing, and bruising substances of considerable hardness. The Fishes of this family seem to have made their first appearance in the later part of the Coal formations; they were very abundant during the Oolitic period; but ceased entirely at the commencement of the Chalk deposit.—Lastly, the ordinary Sharks, constituting the *Squaloid* family, which are distinguished by their sharp lancet-like teeth, have no representatives among the Fossil Fishes of older date; but their remains are first found in the Chalk formations, and extend through all the newer strata down to the present time.—The *Rays*, also, of the earlier periods had teeth more flattened than those of later epochs; and we find from their fossil remains, that some of the forms, which are now regarded as exceptional or aberrant, were formerly more abundant. Thus of the *Myliobatis* or Eagle-Ray (§ 584), of which five species are at present known, fifteen fossil species have been discovered.

590. The *Ctenoid* and *Cycloid* Fishes make their first appearance in the Chalk formation; when all the previously-existing genera of the Ganoid and Placoid orders had become extinct, and when the new ones that were brought into existence were (as we have seen) far less numerous than before. There is, then, a sort of boundary line at the base of the Cretaceous or Chalk deposits, which divides the class of Fishes in a most remarkable manner;—all those below that line, in the order of the strata, or (in other words) all those which existed at a period anterior to the deposition of the Chalk, having belonged to the two first orders, those with enamelled scales;—whilst by far the

larger proportion of those existing at a subsequent time, as at the present epoch, belong to the two orders with horny scales, which comprehend at least three-fourths of the 8000 living species of Fishes known to Naturalists. Of the fossils of these last orders, which abound in the formations of the Tertiary period, it is sufficient to say, that they may nearly all be referred to *families* which have been described as now existing; that many of them belong to the same *genera* with recent Fishes; but that it is doubtful if any of them are of the same *species* with those now tenanting our seas.

591. The sketch here given of the principal groups of Fossil Fishes, is sufficient to illustrate some very interesting points in the history of this class. In the first place, we see that the first-created Vertebrated animals so far resembled the Invertebrated classes, as to possess a very dense external skeleton; whilst their internal skeleton was so soft, as not to be capable of being preserved; and it appears to have been to the Crustacea, which are among the highest of the Articulated series, that these Fishes were most nearly related. On the other hand, among the Fishes of the present time, the *Cyclostomata*, which present the characters of the Vertebrata in their most imperfect form (§ 585), are rather analogous to the *Annelida*, or *Worm* tribe; with which, indeed, some of them were actually classed by Linnæus.—We may next observe, that the covering of dense enamelled scales, in which all the Fishes of the earlier formations were inclosed, rendered necessary a peculiar conformation in the mouths of those, which were destined to prey upon them and to restrain their multiplication. Thus we find the mouths of the predaceous Ganoid fishes, such as the *Holoptychius* and its allies, and in those of the *Cestracionts* and *Hybodonts*, a pavement-like covering of flat enamelled teeth, adapted to crush the hardest substances. But when the enamelled-scaled Fishes had given place to those furnished with a softer covering, we find these enamelled pavements of the jaws replaced by sharp cutting teeth,—the predaceous Ganoids disappearing altogether, and the Cestracionts and Hybodonts giving place to the Sharks.—What was the purpose for which all the earlier races of Fishes were provided

with the enamelled covering so often alluded to, and why these races should have given place at a later period to others so differently constituted, we have no certain means of knowing. It has been suggested by Dr. Buckland, that the purpose of this cuirass may have been, to defend the bodies of the animals against waters that were warmer, or subject to more sudden changes of temperature than could be endured by animals, whose skin was protected only by such thin and often disconnected coverings, as the membranous and horny scales of most modern Fishes. Such changes of temperature were more frequent, there is good reason to believe, in the earlier epochs of the Earth's history, than they are at the present time, for reasons which will be elsewhere explained. (See Treatise on GEOLOGY.)

592. It may be further remarked, that the history of the Fossil Fishes most clearly proves, that the first-created forms of Animal life were not the least perfect,—as some have maintained; and that there is not a regular succession of new races, increasing in elaborateness of structure, from the oldest to the most recent formations. For among the earliest races of Fishes, we find that those of the Sauroid family, which had many characters of *elevation,* held a conspicuous place; and that, when these were replaced by the class of Reptiles, which was called into existence as soon as there was any land for its habitation, they ceased to exist, and were succeeded by races of Fishes which must be regarded as lower in the scale.

CHAPTER VII.

GENERAL CHARACTERS OF ARTICULATED ANIMALS.

593. The animals of which is composed the Sub-Kingdom Articulata, not only present an internal structure which is essentially different from that of the other three divisions of the Animal series, but are likewise distinguished by external characters, which are usually so definite and evident, that they may be almost always recognised at the first glance. Their entire body, in fact, is divided (more or less obviously) into segments; and seems to be composed of a series of rings placed in a line. In some Articulated animals, this *annular* (ring-like) appearance results merely from a certain number of transverse folds, which furrow the skin, and encircle the body; but in the greater number, the animal is enclosed in a sort of solid armour, composed of a series of rings, united one to another in such a manner as to allow them a certain degree of movement. This envelope has uses analogous to that of the internal framework of Vertebrated animals; for it determines the general form of the body; it protects the soft parts; it gives points of attachment to the muscles; and furnishes them with levers, by their action on which the movements may be effected with precision and rapidity. Hence it may be termed an *external skeleton*. It must be borne in mind, however, that the hard substance of which it is composed has no analogy in structure, or in

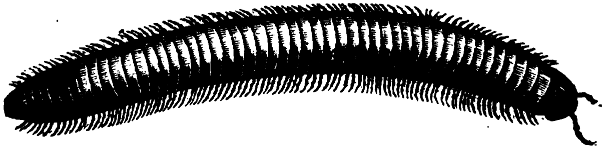


Fig. 287.—Iulus.

mode of growth, with the *bones* of Vertebrated animals. It consists, in fact, of the *skin*, consolidated by the deposition of horny or calcareous matter in its substance; and instead of being able to grow in all directions in the manner of bone, it undergoes very little change when it is once fully formed, and it cannot be made to increase in size except by addition to its edges.

594. The different rings, or segments, of the body of an Articulated animal, always bear a strong resemblance to each other; and sometimes, as in the *Iulus* (Fig. 287), and the *Scolopendra*, or *Centipede*, they seem like actual repetitions of each other. Each ring may bear two pairs of appendages, or members; the one belonging to its *dorsal* arch, or the upper part of the segment; whilst the other belongs to the *ventral* arch, or the under part of the ring. In those Articulata in which the principle of "division of labour" does not yet manifest itself,—that is, in whose bodies we find a number of similar parts adapted to perform the same functions, instead of an assemblage of different parts, constructed each for its own special purpose,—all the segments are provided with these appendages, and their number is sometimes extremely great. But in all the higher tribes, we find the appendages of certain segments attaining a high degree of development; whilst, by a sort of compensating principle, the others present themselves as mere rudiments, or are not even at all discoverable. In general the appendages of the ventral arch are alone developed; and the variety of forms which they

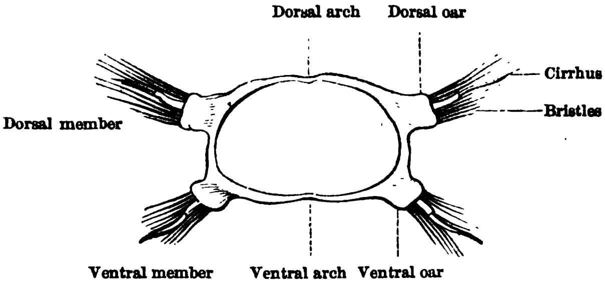


FIG. 288.—VERTICAL SECTION OF A SEGMENT OF AN ANNELIDE, BELONGING TO THE GENUS AMPHINOME.

present is greater, in proportion as the animal is more elevated in the scale. Thus we find them so modified as to become *antennæ*,—those long, horn-like filaments, with which the head is furnished in Insects and Crustacea,—or to be subservient to mastication by being converted into jaws, or to take the form of legs, swimming organs, &c. Of this metamorphosis we shall hereafter notice some remarkable examples in the class Crustacea. Sometimes, however, the appendages of the dorsal arch are present throughout, and perform, like those of the ventral arch, the functions of limbs; of this we find many examples amongst the Annelida. But in general, no more than two pairs present themselves; these are situated on the segments constituting the centre of the body; and they perform the functions of wings or of analogous organs; as we shall hereafter see, when speaking of the class of Insects. The legs are generally 6, 8, 10, or 14 in number; sometimes many hundreds may be counted; and sometimes they are altogether deficient; but when they exist at all, they are never fewer than six, which is the number that is characteristic of the class of Insects. Sometimes instead of distinct legs, we meet with strong bristly appendages, as in the Earth-worm; or bundles of such bristles, in the midst of which one is occasionally a *cirrhus* or tendril-like appendage, constituting a sort of rudimentary leg, as in many Annelida (Fig. 288.)

595. The tendency to repetition exhibited by the segments of the body, is as remarkable in the disposition of the muscles and of the nervous system, as it is in the arrangement of the general envelope. In most animals of this Sub-kingdom, each ring in its complete state possesses a pair of nervous ganglia, united on the central line; and these ganglia are connected together by a double cord of communication, which runs along the lower or ventral surface of the body. In the inferior Articulata, and even in the highest, previously to the completion of their development, these ganglia are nearly

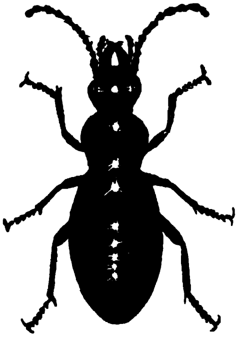
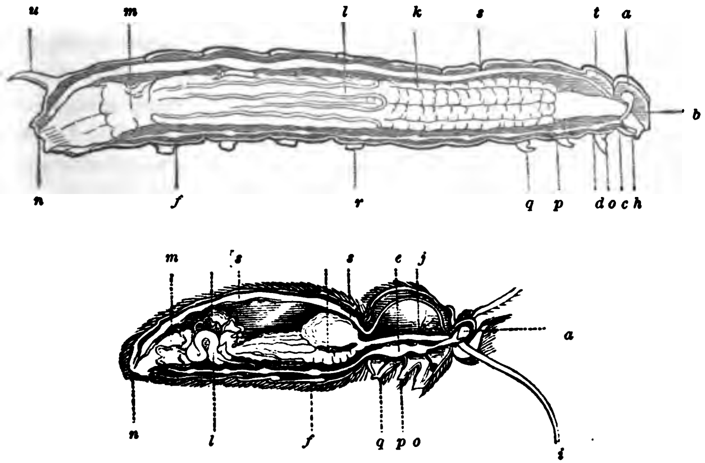


FIG. 289.—NERVOUS SYSTEM OF AN INSECT.

equal, and form with their connecting filaments two chains resembling knotted cords, extending from one end of the body to the other. (Fig. 290.) But in proportion as we rise in the scale, we see the ganglia approach one another, both sideways and lengthwise; so that each pair unites on the central line into a single mass; whilst the ganglia of different segments are also brought together into one spot, and so combined as to form but one large ganglion, —as we shall hereafter notice especially among the Crustacea. This *centralization* is sometimes carried so far, in certain Crabs for example, that there exist in the whole body but two nervous masses,—one in the head, and the other in the thorax (Fig. 466). The ganglia which we find in the head of Articulata have a



FIGS. 290 and 291.—Anatomy of the Caterpillar and Moth of the Privet: *a*, cephalic ganglia, situated in front of the œsophagus, and giving origin to the nerves of the eyes, &c.; *b*, cords which unite these ganglia to those of the second pair, passing on either side of the œsophagus, so as to form a collar round it; *c*, first pair of sub-œsophageal ganglia; *d*, ganglion of the first segment of the thorax, followed in the Caterpillar by others at regular intervals; *e*, nervous mass in the Moth, formed by the ganglia of the second and third thoracic segments; *f*, abdominal ganglia; *h*, mouth; *i*, trunk; *j*, œsophagus; *k*, stomach; *l*, intestine and biliary vessels; *m*, large intestine; *n*, anus; *o*, legs of the first pair; *p*, legs of the second pair; *q*, legs of the third pair; *r*, first pair of membranous legs, in the Caterpillar; *s*, dorsal vessel; *t*, first segment of the thorax; *u*, horny appendage at the extremity of the abdomen of the Caterpillar.

manifest correspondence to those of certain parts of the brain in Vertebrata. They are *not* the representatives of the Cerebral hemispheres, which are peculiar to the latter; but they obviously resemble the Optic and other ganglia of special sense, which we find even in the highest Vertebrated animals, at the origin of the nerves that proceed to those organs, and which in Fishes make up so large a proportion of the entire brain, as frequently to surpass in size the cerebral hemispheres themselves (§ 530). The ganglia of the ventral cord are so many centres of *reflex* action to the different segments which they supply (ANIM. PHYSIOL. § 442); and in this respect they are analogous to the Spinal Cord of Vertebrated animals, from which they differ in no important particular, except in their position. Even in this, however, there is a greater resemblance than is at first apparent; for there is strong reason for regarding the usual position of Articulated animals as really *inverted;* that is, for considering what is apparently the *ventral* surface of the body as in reality the *dorsal*, and the apparent *back* as the real *abdomen*.

596. The bulk of the body in the Articulata is made up of the muscles, by which the several segments, and their various appendages, are put in motion. These muscles, like the parts of the body themselves, are arranged with great regularity and exactness on the two sides of the median or central line; so that the *lateral symmetry* (§ 47) of the Articulata is most exact. We shall hereafter see that this symmetry extends in great degree also to the organs of nutrition; which in the Vertebrata are not arranged with the same equality. Where the segments and their appendages have a similar form and action, their muscles are but repetitions of each other; but where, as in the higher Articulata, the segments and their appendages are differently constructed, the muscles also are more variously arranged, and often form a system of great complexity.

597. The development of the organs of Nutrition in Articulated animals would seem to be altogether subservient to that of the Locomotive apparatus;—their function being chiefly to supply the nerves and muscles with the aliment necessary to sustain their vigour. The power of these muscles is so great in propor-

tion to their size, that, in energy and rapidity of movement, some of the Articulated tribes surpass all other animals. These movements are directed by organs of sensation; which, although not developed on so high a plan as those of some Mollusca, are evidently very acute in their powers. There are very few instances of Articulated animals being in any way restrained as to freedom of locomotion; and these are for the most part found in a single group, the CIRRHIPODA, or *Barnacle* tribe, which connects this sub-kingdom with the preceding. In general they roam freely abroad in search of food; and they are supplied with prehensile organs for capturing their prey, and with a complex masticating apparatus for reducing it. Their actions are evidently directed almost solely by *instinctive* propensities, which are adapted to meet every ordinary want; these are of similar character in each individual of the same species, and present but little appearance of ever being modified by Intelligence. Hence these animals seem almost like machines, contrived to execute a certain set of operations; many of them, however, producing immediate results, which even Man, by the highest efforts of his reason, has found it difficult to attain.

598. All the Articulata, save a few of the very lowest species, possess a distinct head at one end of the body, furnished with organs of special sensation, and with jaws for the prehension and reduction of the food. These jaws do not open *vertically*, however, as in the Vertebrata, so as to leave a horizontal aperture; but *laterally*, so as to leave a vertical aperture: and there are frequently several pairs of them, one behind the other, sometimes furnished with sharp cutting edges, sometimes having their edges toothed like a saw, and sometimes adapted to crush rather than to cut or tear. The alimentary tube frequently passes straight along the central line, from one extremity of the body to the other, with a dilatation near its commencement,—the stomach: and where this is not the case, the convolutions which the intestine makes are usually few in number. Instead of a heart, we find a *dorsal vessel* (*s*, Figs. 290 and 291), a long tube placed on the central line of the back, and divided into segments, corresponding with those of the body,—each seg-

ment being, as it were, the heart for its own division. The respiratory apparatus, too, is arranged with the most perfect symmetry. In the lower tribes, and in the Crustacea, it is adapted to act in water; and consists of gills or branchial appendages, of various forms, which are prolonged from the exterior of the body. But in Insects and Spiders, which constitute the great majority of the class, the respiration is aerial; and is performed by an apparatus consisting of a set of chambers or tubes, which are dispersed or extended through the whole body. By this means, the air, the blood, and the tissue to be nourished, are all brought into contact at the same points; and a much less vigorous circulation is required, therefore, than would otherwise be needed. The whole apparatus of Nutrition is comprised within a comparatively small part of the body, in the higher classes at least; and the bulk of the organs composing it is never to be at all compared with that, which we ordinarily find in the Mollusca. Thus the Liver, which in the Oyster forms a large part of the whole substance, is often scarcely discoverable in the Insect; and where (as in the Crustacea) its bulk is considerable, it is because the respiration, being aquatic, is less active than usual, and is consequently not sufficient to draw off the superfluous carbon from the blood (ANIM. PHYSIOL. § 365). The blood is usually white, as in other Invertebrated classes; and where it is otherwise (as in some of the Annelida), it is in the liquor sanguinis, and not in the corpuscles, that the colour exists,—these last being analogous to the *colourless*, and not to the *red* corpuscles of the blood of Vertebrata. The temperature of Articulata usually varies with that of the air or water they inhabit; but in the class of Insects we find many, which have the power of generating a large amount of independent heat; and this is strictly proportional to the quantity of oxygen converted by them into carbonic acid, by the respiratory process. All the actions of the Articulata are performed with great energy; and at the time of the most rapid increase of the body, the demand for food is so great, that a short suspension of the supply proves fatal. Many of them, however, are capable of being submitted to the influence of very high and of very low temperatures, with little permanent injury.

599. The division of this Sub-kingdom into Classes, is principally founded on the organs of locomotion; which, as we have seen, are so characteristic of it. We may first form two groups, distinguished by the presence, or absence, of *distinctly-articulated members*. In the former, the locomotive power is for the most part consigned to these appendages; and the trunk is usually encased in a hard envelope, in which, by the union of segments that were originally distinct, we sometimes almost lose the traces of the characteristic division. This is especially the case with the Crab and its allies; in which the different parts of the body are quite immoveable upon each other. On the other hand, in the lower group, in which distinct members are wanting, the locomotion of the animal is chiefly effected by the movement of the body itself; and this is permitted to the utmost extent, by the softness of the integument, in which the intervals of the articulations are scarcely distinct from the rings themselves,—as in the Leech or Earth-worm,—so that here, too, the division into segments becomes indistinct, from the opposite cause. It is in the Centipede (Fig. 292) that we have the best example of the division of the body into segments, which is characteristic of the entire group; together with an articulated structure in the limbs. In the classes of Insects, Crustacea, Spiders, &c., the equality of the segments disappears; whilst in the Leech and Worm tribes, the members disappear.

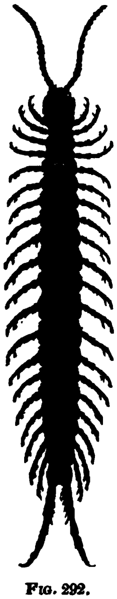


FIG. 292.
CENTIPEDE.

600. The higher division of the Articulated series may be arranged into the following classes:—

I. INSECTS; characterised by the division of the body into *three* distinct portions,—the head, thorax, and abdomen; by the possession of antennæ on the head, of *three* pairs of legs, and (in general) of one or two pairs of wings; and by their aerial respiration.

II. ARACHNIDA, including the *Spiders*, *Scorpions*, and *Mites*;

characterised by the division of the body into *two* distinct portions, the cephalo-thorax (made up of the head united to the thorax) and abdomen; by the possession of *four* pairs of legs; by their want of antennæ; and by their aerial respiration.

III. CRUSTACEA, or *Crabs*, *Lobsters*, &c.; distinguished by their aquatic respiration; and by the possession of from *five* to *seven* pairs of legs; the body sometimes divided nearly as in Insects, sometimes even more concentrated than in the Arachnida, and sometimes formed on the plan of that of the Myriapoda.

IV. MYRIAPODA, the *Centipede* tribe; characterised by the want of distinction between thorax and abdomen; by the equality of the segments of the body,—the head, however, being very distinct; by the large number of legs, of which there are seldom less than twenty-four pairs; and by their aerial respiration.

Intermediate in some respects between the two divisions of this Sub-kingdom, we may rank the following remarkable group:—

V. CIRRHOPODA, or the *Barnacle* tribe; in these, there are no locomotive members in the adult, although the young possesses them; there are, however, a series of jointed tendril-like appendages, which probably serve both for respiration and for the acquirement of food; and the animals remain attached to one spot, during all but the early period of their lives; their respiration is entirely aquatic.

601. In the Second division of Articulata, characterised by the absence of articulated members, we meet with but three classes.

VI. ANNELIDA, the *Leech* and *Worm* tribe; characterised by the extension of the body into numerous segments, which present scarcely any differences from each other; by the presence of a distinct circulating system, and of respiratory organs; and by the possession of a well-developed nervous system.

VII. ENTOZOA, or *Intestinal Worms*, in which the Articulated form is presented in (as it were) a still more degraded state; the segments being yet more completely repetitions of one another, and often capable of existing separately; special organs of circulation and respiration being for the most part wanting;

and the nervous system being very indistinct,—never presenting the double ventral cord in a well-developed condition: these have very frequently no distinct head.

VIII. ROTIFERA, or *Wheel-Animalcules*, a group of minute animals, in which the Articulated structure is often very indistinct, and which are especially characterised by the possession of *cilia*, or little hair-like filaments, arranged in rows in the neighbourhood of the mouth, and serving by their movements, both for the acquirement of food, and for the aeration of the fluids of the body.

CHAPTER VIII.

OF THE CLASS OF INSECTS.

602. THE class of Insects is pre-eminent, not only amongst the divisions of the Articulated series, but in the whole Animal kingdom, in regard to the number of distinct *species* which it includes; and it is probably unsurpassed by any, save the Infusory Animalcules, in regard to the number of *individuals* at any time existing on the earth's surface, which belong to the numerous and diversified races comprehended in it. The whole sub-kingdom of Vertebrated animals may probably be estimated as not containing above 30,000 species,—a number which is surpassed by the *Beetle* tribe alone; and we should be probably not far wrong in saying, that the number of species of the whole class, already known, exceeds that of all other animals put together. Moreover, on account of the small size of *all*, and the very minute size of a large proportion, of the animals belonging to this class, it is probable that the number of species already known is far surpassed by that which remains to be discovered. Even in our own country, new species of Insects are continually being discovered, by the industry of observers who devote themselves to this particular branch; and the number at present unknown must of course be far greater, in countries that have been less completely explored. Of the importance of this class in the economy of Nature, several striking proofs will be given hereafter.

603. The tegumentary skeleton of Insects, that is to say, the hard skin of these animals, sometimes preserves a certain degree of flexibility; but generally presents a consistency analogous to that of horn. It must not be thought, however, that its tissue is really of that nature; for Chemistry teaches us that it is composed of very different materials, and that a particular

substance named *Chitine*, forms the base of it; but there is reason to believe, that it possesses a definite organic structure; and that it consists of one or more layers of cells, in the cavities of which this substance is deposited. We see in it a great number of pieces, which are sometimes soldered (as it were) together; whilst in other instances they are united by soft portions of the skin, and thus possess a greater or less freedom of motion.

604. The body of the Insect, as we have already said, is divided into a certain number of rings, placed end to end; and in this series of segments, we distinguish three portions, to which are given the names of *Head, Thorax*, and *Abdomen*. The members or appendages which spring from the several segments, have a structure analogous to that of the trunk of the animal: being composed of tubes or of hollow plates, placed end to end, and enclosing in their interior the muscles and nerves destined to put them in motion.

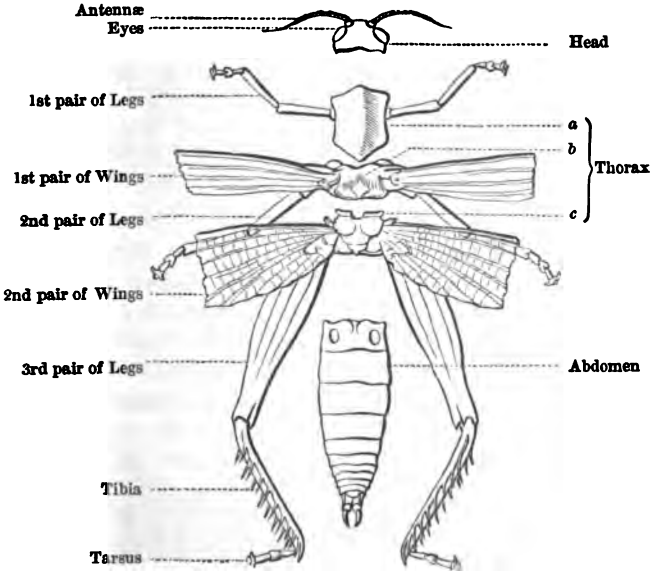


Fig. 293.—Anatomy of the external Skeleton of an Insect.

605. The head is formed only by a single piece; and bears the eyes, the antennæ, and the appendages of the mouth. The *antennæ* constitute the first pair of members or appendages of Insects; and are composed of a considerable number of small joints placed end to end; they arise from the anterior or superior part of the head; and generally have the form of slender and flexible horns (Fig. 294, *a a*); but their conformation varies much, especially amongst the males; thus they sometimes resemble feathers, sometimes saws; at another time small bulbs (Fig. 295); and in other instances they are terminated by an enlarged part composed of layers placed like the leaves of a book. Their length is sometimes very considerable. We know nothing positive regarding their use; but it is supposed that they are organs of feeling, and perhaps also of hearing (ANIM. PHYSIOL. § 498). Other appendages, to the number of three pairs, spring

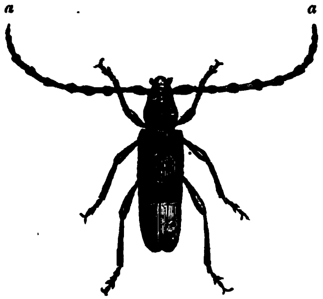


FIG. 294.—CAPRICORN BEETLE.
a, a, antennæ.

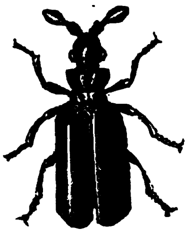


FIG. 295.—PAUSSUS CORNU.

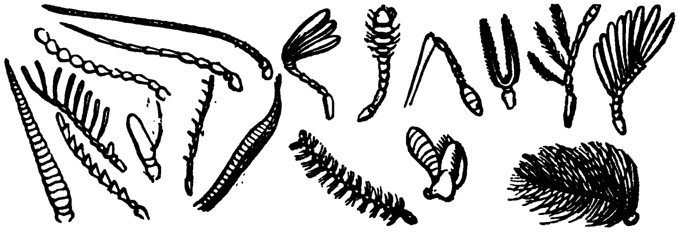


FIG. 296.—VARIOUSLY-FORMED ANTENNÆ OF INSECTS.

from the inferior part of the head, and constitute the organs of mastication or of suction; we shall return to these, when speaking of the Digestive apparatus.

606. The *thorax* of Insects occupies the middle part of their body; and bears the legs and the wings. It is always composed of three rings, named *prothorax*, *mesothorax*, and *metathorax* (Fig. 293, *a*, *b*, *c*); and to the ventral arch of each of these segments, is fixed one of the pairs of legs. The wings arise, on the contrary, from the dorsal arch of the thoracic rings; but the prothorax never bears them, and there never exists more than one pair of these appendages on each of the succeeding rings; so that their number can never exceed two pairs.

607. We may distinguish, in the limbs of Insects, a haunch composed of two joints, a thigh, a shank, and a kind of finger, named *tarsus*, which is divided into several joints whose number varies from two to five, and is terminated by claws. Their conformation differs; but, as may be readily believed, it is always in relation with the habits of the animals. Thus the Insects whose posterior legs present a great length (Fig. 297), usually jump rather than walk; amongst the swimming insects, such as the *Dytiscus*, the *Notonecta* (Fig. 298), and the *Gyrinus*, vulgarly called Whirligigs (Fig. 299), the tarsi are usually flattened, fringed with hairs, and arranged like oars; and amongst those which can walk suspended from smooth surfaces, we find, under the last joint of these organs, a kind of cushion or cup, fitted to make them adhere to the body which they touch. Sometimes, also, the anterior legs are widened like those of the Mole, in order to enable them to dig in the ground; the *Mole-Cricket*, which often occasions considerable injury in our fields,

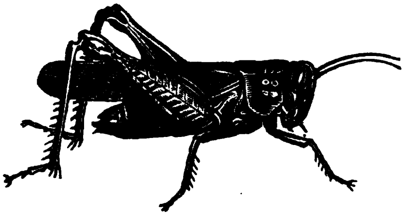


FIG. 297.—LOCUST.

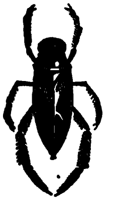


FIG. 298.—NOTONECTA.

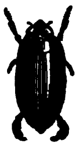


FIG. 299.—GYRINUS.

by cutting the roots which it finds in its way, presents us with a remarkable example of this form of structure. There also exist some species, amongst which these same limbs constitute organs of prehension, the leg being disposed in the manner of a claw, and being able to bend itself back against the preceding joint, of which the edge is armed with spines. A large insect from the South of France, the *Mantis religiosa*, is formed in this manner. Again, we meet with some insects, amongst which the anterior legs are reduced to a rudimentary state, and bent back against the thorax, no longer serving for its movements, and easily escaping notice, so that at first sight we should believe these animals were provided with only four legs; several diurnal Butterflies are in this condition (Fig. 302).

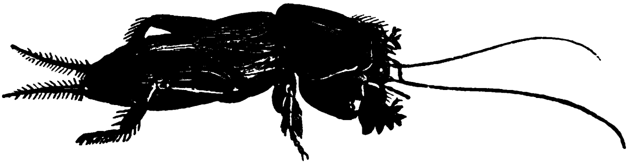


FIG. 300.—MOLE-CRICKET.

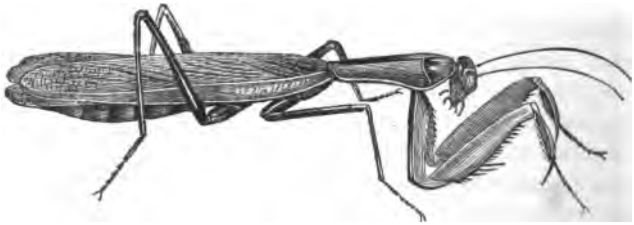


FIG. 301.—MANTIS RELIGIOSA.

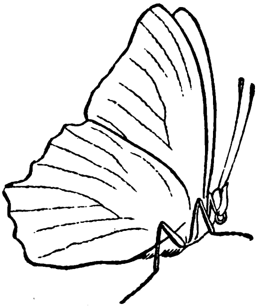


FIG. 302.—MORPHO.

608. The wings of Insects are leaf-like appendages, composed of a double membrane, supported on the inside by a more solid framework. When they are but slightly developed,

they are soft and flexible; but they soon dry up, and remain stiff and elastic. In general there are two pairs; we never find a greater number, but sometimes one or other of these pairs is wanting; and it is always from the last two rings of the thorax that they arise. Their form varies; when they really serve for flight, they are thin and transparent, except when lightly covered with a kind of coloured dust, formed by scales of a microscopic minuteness, such as we see amongst the Butterflies; but often those of the first pair become thick, hard, and opaque, and constitute a kind of sheath or casing, named *elytra* (*a*, Fig. 303), which, in a state of rest, covers over the membranous wings (*b*), and serves to protect them; at other times these same wings, still membranous at their extremity, become hard and opaque towards their base, and are then designated under the name of demi-casings or *hemelytra*. We are acquainted, also, with some insects, amongst which the wings, instead of having a leaf-like structure, are divided into a number of membranes, barbed along the edges, so as to resemble feathers arranged in a fan-like manner; this is seen in a genus allied to the Butterflies, and known under the name of *Pterophorus*, or *Plumed-Moth*.

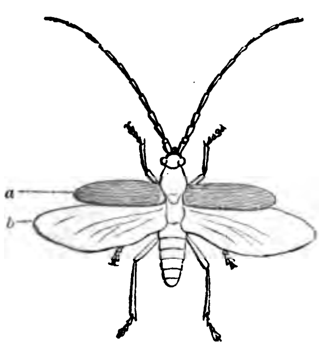


FIG. 303.

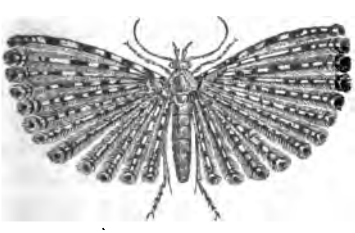


FIG. 304.—PTEROPHORUS.

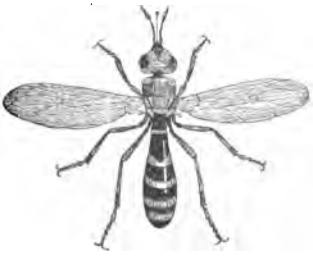


FIG. 305.—CONOPS.

Again, when the posterior wings are wanting, they are generally replaced by two small moveable threads, thickened at the end, which are called balancers (Fig. 305).

609. The abdomen of Insects is composed of a considerable number of rings, moveable upon each other; we can frequently reckon nine of these; but at other times we cannot distinguish so many; this appears to depend on the union of two or more of these segments with each other. In the perfect Insect, these rings never bear any legs or wings; but those which occupy the posterior extremity of the body, often give attachment to appendages, whose forms and uses vary very much. Sometimes they are simple bristles, or points, whose functions are not well known; as in the *Ephemera* (Fig. 334) for example. Sometimes these organs possess the form of hooks; and constitute a more or less powerful pair of pincers, as amongst the *Forficulæ*, or Earwigs (Fig. 306). At other times they are so arranged, as to act as a spring, and to enable the animal to throw itself forwards; the *Poduræ*, or *Spring-tails*, — small insects, which, in our climate, conceal themselves under stones, or keep themselves on the surface of still water, and which also live sometimes in the snow of the coldest regions of the globe, show this mode of organisation. Again, in other instances, these abdominal appendages have a more complicated structure, and constitute an offensive weapon, or an apparatus destined to effect the deposit of the eggs laid by the animal in a place fitted for the development of its young; as examples of these organs, we may mention the retractile sting of the Wasps and Bees, and the piercer of the Tenthredos, or Saw-flies. The former is composed of a dart, formed of two sharp-pointed processes, placed within a horny sheath, or case, and having in each a furrow (completed into a canal by the union of the two) through which the poison

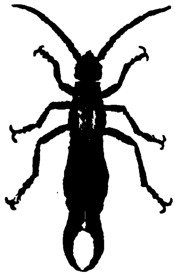


FIG. 306.—FORFICULA.

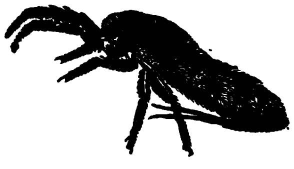


FIG. 307.—PODURA.

flows, that is secreted by a small gland which is situated very near. In a state of repose all these pieces are drawn within the body of the animal; but when the insect wishes to use it, he causes the sheath to project, and buries it, together with his dart, in the skin of his enemy. Sometimes it is even impossible for him to draw it out; the whole sting is then separated from the body, and remains fixed in the wound. The injury which results from this, quickly causes the death of the insect. The male is always destitute of this weapon; hence it may be seized without danger: but the females, and generally the sterile individuals, called *workers*, are provided with it: the puncture causes a painful inflammation.—The *borer* of the Ichneumons, of the *Fœnus* (Fig. 308), and of many other insects, shows an arrangement very analogous; and we generally observe in it a kind of small saw, by the aid of which the insect pierces the vegetable or animal tissues in which it desires to deposit its eggs. It is by thus piercing a species of oak, in the Levant, that the small insect, known by the name of *Cynips*, or Gall-fly, causes the formation of the Gall-nuts, of which so much use is made in the manufacture of ink, and in the preparation of black dyes. The small puncture effected by the *Cynips* causes an overflowing of the vegetable juices, and there soon results from this, an excrescence, in the centre of which we find the eggs, or larvæ, of the insect.

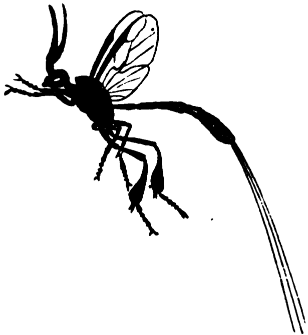


FIG. 308.—FŒNUS.

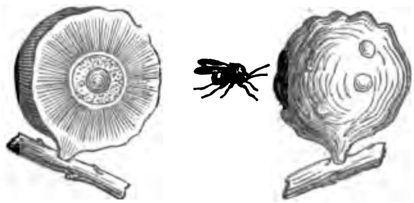


FIG. 309.—THE INK-GALL INSECT, AND THE INSECT BY WHICH IT IS PRODUCED.

610. Insects are provided with highly developed senses; they evidently possess Hearing and Smell, as well as Taste, Sight and Touch; but even now the seat of the sense

of Smell has not been certainly discovered; and amongst the greater part of these animals, no special organ of Hearing can be perceived. The antennæ, and the appendages of the mouth, seem to be the principal instruments for Touch; and the former may, perhaps, also serve for the perception of Sound. We also know very little of the apparatus for Taste; but the organs of Sight have been better studied.—The structure of the Eyes is very different from that which we have seen amongst the higher animals. In general, the organ which at first sight appears to be a single eye, is, in reality, formed by the aggregation of a multitude of small eyes, each having a cornea, a vitreous body of a conical form, a layer of colouring matter, and a separate nervous filament. In the common House-Fly, for example, we can reckon four thousand of these distinct eyes; and some insects are known, which have more than twenty-five thousand. All these little corneas are hexagonal, and are united together, so as to form a kind of common cornea, whose surface presents a number of divisions, resembling the meshes of a net, visible only by the aid of a magnifying glass. (See ANIM. PHYSIOL. §§ 573, 574). Moreover, each of the small eyes, which altogether make up these compound organs, is perfectly distinct from those which surround it, and forms with them a bundle of tubes, each terminated by a nervous thread proceeding from a bulbous expansion of the same Optic Nerve. Nearly all Insects are furnished with two of these compound eyes, usually placed on the sides of the head; but sometimes they are replaced by *simple eyes;* and in other instances these two sorts of organs exist together. The structure of simple eyes, which are known also by the name of *stemmata* or *ocelli*, has the greatest analogy with that of each of the elements of the compound eyes. The simple eyes are generally united in a group, to the number of

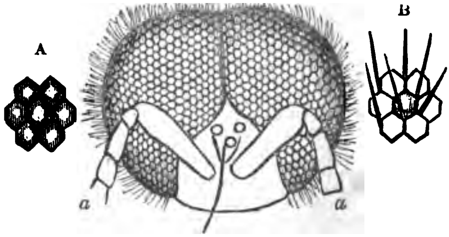


FIG. 310.—Head and eyes of the Bee: *a, a*, antennæ; A, facets enlarged; B, the same with hairs growing between them.

three, towards the top of the head. We know nothing certain of the manner in which these organs act upon the light that falls upon them; nor of the mechanism of vision amongst Insects.

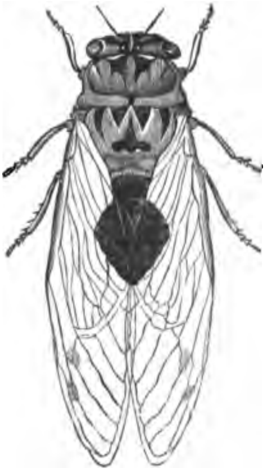


FIG. 311.—CICADA.

611. Several Insects possess, in common with the higher animals, the faculty of producing sounds: but in general their song is not connected with the movements of the air in the respiratory apparatus, as amongst the former; and depends upon the rubbing of certain parts of the body against each other, or on the movements produced in certain special instruments, by the contraction of muscles. Thus the monotonous and deafening noise of the *Cicada* results from the alternate tension and relaxation of an elastic membrane, placed like the skin of a drum upon the base of the abdomen; amongst the Crickets, there are certain parts of the wings, which, when rubbed against each other, vibrate with intensity, and which have a very curious structure for this purpose; but the humming of Flies appears to depend upon the rapid exit of the air through the thoracic spiracles, during the violent movement of flight. Again, there are some Insects that utter a kind of cry, the manner of producing which is not well known; such is the *Sphinx Atropos*, known under the name of the Death's-head Moth. (ANIM. PHYSIOL. §§ 676—679).

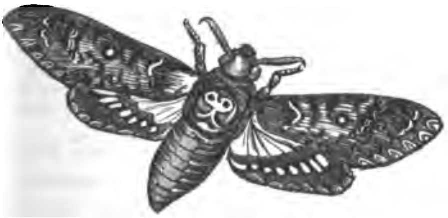


FIG. 312.—SPHINX ATROPOS.

612. The Nervous system of Insects shows the general arrangement, and the chief part of the modifications, which we have already described in treating of the Sub-kingdom, to which these animals belong (§ 595). It is principally composed of a double series of ganglia, which are united together by longitudinal cords; the number of these ganglia corresponds with that of the segments; and they are sometimes at nearly equal distances, and extend from one end of the body to the other, whilst in other instances several of them are connected together in such a manner, as to constitute a single mass. The cephalic ganglia present a very high development, and give origin to the nerves of the Antennæ and of the Eyes, &c. The first pair of ganglia below the œsophagus supplies the nerves of the mouth; and the cords which unite these nervous centres to the cephalic ganglia, and which pass round the œsophagus, give off on each side a nerve which goes back to the stomach; and which joining itself with that of the opposite side, forms a single trunk, running on the central line above the digestive canal, and having two ganglia in its course. The three pair of ganglia on the ventral cord, following those which are situated immediately beneath the œsophagus, belong to the three rings of the thorax, and are the points of departure of the nerves of the feet and the wings; in general they are very close together, and are much larger than the succeeding pairs, which belong to the abdomen.

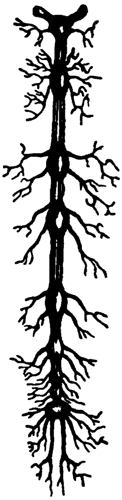


FIG. 313. NERVOUS SYSTEM OF INSECT.

613. The manner in which Insects are nourished, varies very much; some only live on the juices of plants and animals, others feed on solid food, and are either carnivorous or devourers of plants; and these differences correspond with remarkable modifications in the structure of the mouth. Amongst *gnawing* insects, such as Beetles, Cockchafers, Cockroaches, and Locusts, this opening is furnished in front with a central piece, named *labrum*, or upper lip (*a*, Figs. 314 and 315); and has on each side a kind of large tooth, moveable and very hard, called the *mandible*, or upper jaw (*b*),

which serves to divide the food. Immediately behind these mandibles is found a second pair of appendages, whose structure is very complicated; these are the second pair of jaws, termed the *maxillæ* (*c*). Each of these last organs has on the inside a plate or cylinder, of greater or less hardness, generally armed with notches or hairs, and having on the outside one or two small appendages composed of several joints, and termed *maxil-*

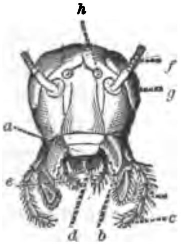


FIG. 314.
HEAD OF COCKCHAFER.
a, labrum; *b*, mandibles; *c*, maxillæ; *d*, tongue; *e*, labial palpi; *f*, antennæ; *g*, compound eyes; *h*, ocelli.

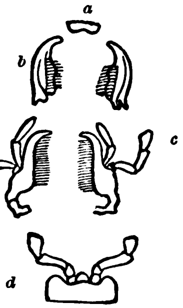


FIG. 315.—PARTS OF THE MOUTH OF CARABUS;—*a*, labrum; *b*, mandibles; *c*, axillæ; *d*, labium.

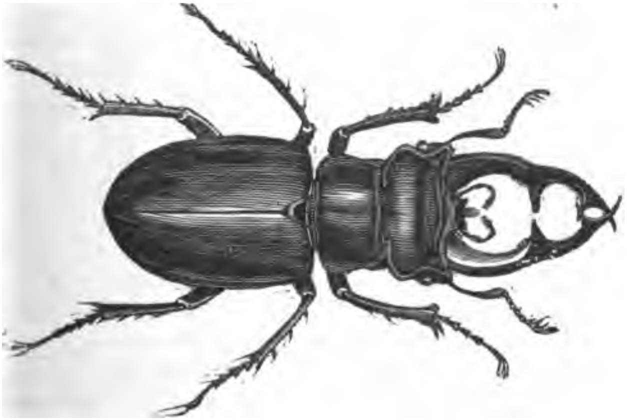


FIG. 316.—STAG-BEETLE.

lary palpi. Again, behind the maxillæ is found a second pair of appendages, whose base is supported by a central piece, called the *mentum*, or chin. These appendages constitute the tongue (*d*, Fig. 314); they are applied against the maxillæ, as these organs are themselves applied against the mandibles. We have further to mention a second pair of jointed moveable appendages, or palpi; which are termed *labial palpi*,—the name of *labium*, or lower lip, being commonly given to the piece formed by the union of the tongue and mentum (*d*, Fig. 315). The form of these various parts differs according to the nature and consistency of the food. The palpi serve principally for seizing the food, and holding it between the mandibles whilst these divide it. Sometimes the maxillæ have an enormous development, and form a large pair of pincers on the front of the head; an arrangement which is very remarkable among the Stag-beetles, and other species of the genus *Lucanus* (Fig. 316).

614. Amongst the *sucking* Insects, the maxillæ or the labrum are lengthened, so as to constitute a tubular trunk; in the interior of which we frequently find delicate filaments, performing the functions of small lancets, and formed by the mandibles and maxillæ modified to such a degree as to be hardly percep-

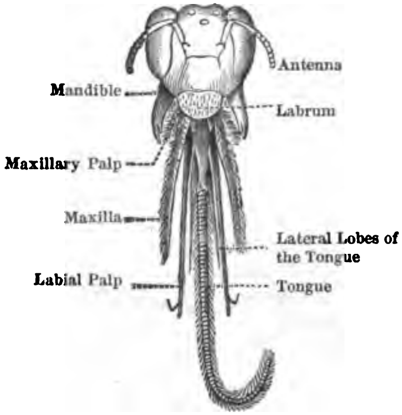


Fig. 317.—Head of Anthophora.

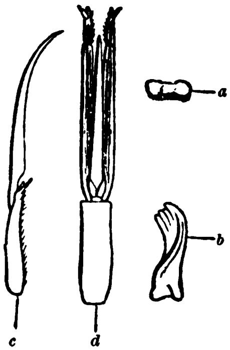


Fig. 318.—Parts of the mouth separated.

tible. Amongst the Bees, the Anthophoræ, or solitary Bees, the Humble Bees, and other Insects known by Zoologists under the name of *Hymenoptera*, the *buccal* apparatus * presents an arrangement, which is in some degree intermediate between these two extreme states. The labrum and the mandibles much resemble those of the gnawing Insects, and offer nothing very peculiar in their form and structure (*a* and *b*, Fig. 318); but the maxillæ (*c*) and the tongue (*d*) are greatly elongated; and the former have a tubular form, and inclose longitudinally the sides of the tongue; so that these organs, united into a bundle, form a canal that serves for the passage of the food, always soft or liquid, by which these Insects are supported. This tube is moveable at its base, and flexible during the remainder of its length; but it is never rolled up, as we shall find amongst the Butterflies. The mandibles serve only to divide the materials, of which the Hymenoptera make their nests; or else to seize and put to death the prey, whose juices these Insects suck. It is also to be observed, that there exist within the buccal cavity other solid pieces which are wanting amongst the gnawing insects; and which constitute valves destined to close the pharynx, whenever the movement of deglutition is not going on.

615. Amongst the Cicadæ, the Bugs, and other insects of the order *Hemiptera*, the apparatus for suction is composed of the same elements; but these present a somewhat different arrangement. The mouth is armed with a tubular and cylindrical proboscis, directed downwards and backwards (Fig. 319), and composed of a sheath inclosing four bristle-like prolongations, or setæ; the sheath (*a*, Fig. 320) is composed of four joints, placed end to end, and representing the labium or under lip; at its base we perceive a conical and elongated piece, which is analogous with the labrum; lastly, the *setæ* (*b*, *c*), which have the form of fine threads, stiff and jagged at their points to be

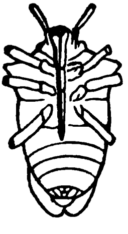


FIG. 319.—BUG.

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* The term *buccal* refers to that which belongs to the mouth; and the above expression is conveniently applied to denote the several parts collectively, which altogether make up the mouth, in whatever way they may be arranged.

able to pierce the skin of animals or the vessels of plants, are the representatives of the mandibles and the maxillæ extremely elongated. In those Hemiptera which live at the expense of other animals, the proboscis is usually very firm, and folds into a semicircle under the head. Among those which are nourished by sucking vegetables, on the contrary, it is nearly always thin, and is laid when in a state of rest against the lower side of the thorax, between the feet. Its length is sometimes so considerable, that it passes backwards behind the posterior extremity of the abdomen.

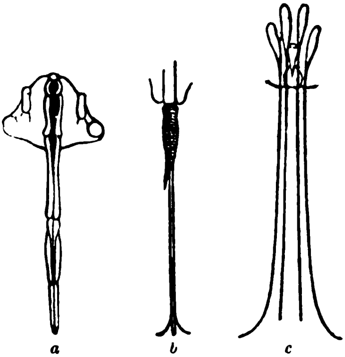


FIG. 320.—BUCCAL APPARATUS OF AN HEMIPTEROUS INSECT.

616. Amongst the Flies, also, the proboscis, which is sometimes soft and retractile, sometimes horny and lengthened, represents the under lip, and often bears palpi at its base; a longitudinal channel occupies its upper side, which incloses the *setæ*; whose number varies from two to six, their analogues amongst the gnawing insects being the mandibles, the maxillæ, and the

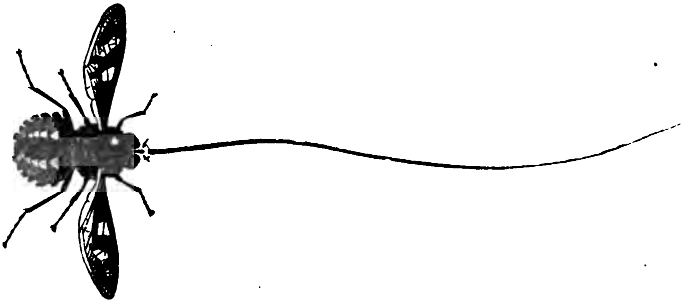


FIG. 321.—NEMESTRINA LONGIROSTRIS.

tongue. Sometimes this proboscis acquires an enormous length (Fig. 321); sometimes on the contrary it is hardly visible.—Lastly, among the Butterflies, which are also supported on liquid substances, but which find them at the bottom of the flowers, and therefore have no occasion for instruments to procure them, there exist no *setæ* performing the functions of lancets, as among the preceding; and the mouth is furnished with a long tubular trunk, coiled into a spiral, and composed of two slender filaments, each channelled on its internal edge, so that a tube is formed by the adhesion of the two; these are nothing else than the maxillæ very greatly lengthened and modified in their form. At the base of this tube is seen a small membranous piece, which is the representative of the labrum; and on each side, a small tubercle, the only vestige of the mandibles. We also perceive the rudiments of the maxillary palpi; and behind is found a small triangular labium, having two very large labial palpi, composed of three joints, and nearly always clothed with scales.

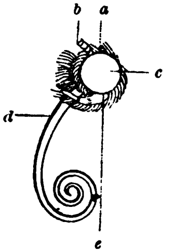
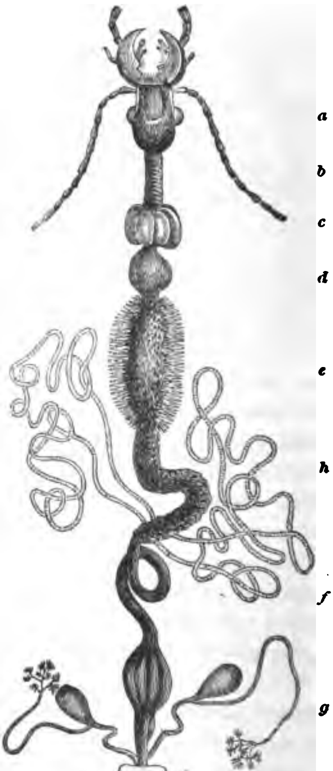


FIG. 322.—TRUNK OF A BUTTERFLY; *a*, head; *b*, base of antennæ; *c*, eye; *d*, trunk; *e*, palpi.

FIG. 323.—MORPHO HELENOR.

617. The alimentary canal generally presents a very complicated structure: sometimes it is straight, and has very nearly the same diameter throughout its entire length; but usually it is more or less convoluted, and has several successive enlargements, and contractions. We may distinguish in it (Fig. 324), a pharynx (*a*), an œsophagus (*b*), a first stomach or crop (*c*), a second stomach or gizzard (*d*), of which the walls are muscular and often armed with horny pieces fitted to triturate the food; a third or true digestive stomach (*e*), whose texture is soft and delicate; a small intestine (*f*), a cœcum, and a rectum (*g*). As

we see amongst the higher animals a connection between the nature of the food and the development which this canal acquires, so among the Carnivorous Insects it is generally very short; whilst among Insects which are supported on Vegetable substances, it is usually very long. The food which enters it, is at first moistened with the saliva; the apparatus which secretes this liquid consists of a certain number of floating tubes, terminated sometimes by small follicles or sacs, and communicating with the pharynx by their excretory canals. A multitude of *villi*, with which the digestive or chylific stomach is generally furnished, appear to serve for the secretion of a gastric juice; and it is also into this cavity, that the bile is poured. There does not exist any liver, properly speaking, among Insects; but this organ is replaced by long and delicate tubes (*h*), which float in the interior of the abdomen, and open high up in the chylific stomach. (Similar vessels, opening lower down, take the place also of the urinary glands; for uric acid has been found to be secreted in them.) By one of their extremities, the biliary vessels always open into the chylific stomach; and the other extremity is sometimes free, but sometimes fixed to the intestine, either near the first opening



324.—Digestive Apparatus of Beetle; *a*, pharynx; *b*, œsophagus; *c*, crop; *d*, gizzard; *e*, chylific stomach; *f*, small intestine; *g*, rectum; *h*, biliary vessels.

or close to the rectum. Lastly we find, towards the extremity of the intestinal canal, other secreting organs, that serve to elaborate particular liquids (such as the poison of the Bee's sting), which several Insects can throw out from the extremity of their abdomen, when they are irritated.

618. It would appear to be by simple absorption, that the chyle traverses the walls of the digestive tube and mixes with the Blood. This liquid is watery and colourless; it is not everywhere inclosed in vessels, but spreads itself out into the interstices, which exist between distinct organs, or which present themselves in the substance of their tissue. Insects are destitute of a regular circulation. We can clearly see very rapid currents in certain parts of the body; but the nourishing liquid does not perform a circle in such a way as to return constantly to the point of its departure. There really exist amongst these animals only vestiges of a circulating apparatus.

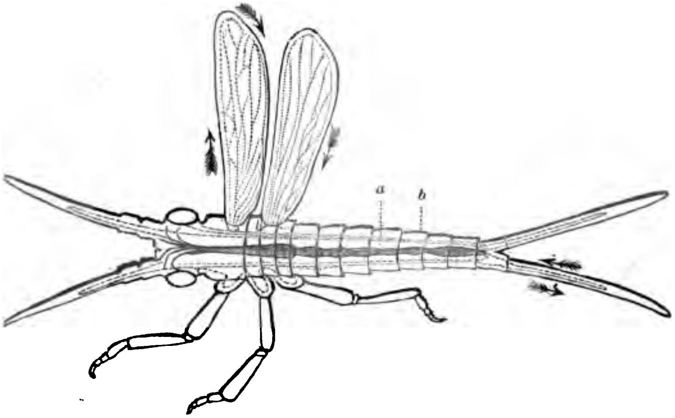


FIG. 325.—CIRCULATION IN INSECTS.

We see near the dorsal surface of the body a longitudinal tube (*a*, Fig. 325), which performs alternate movements of contraction and dilatation, analogous to those of the heart among the higher animals. The nourishing liquid penetrates into it by lateral openings, furnished with valves to prevent its reflux; and being propelled forwards by the successive contractions of its different chambers, it passes out in front by a series of canals, of which some convey it to the head, whilst others pass sideways and backwards (*b*), for the supply of the body with its appendages, the legs and wings. On returning from these parts, it re-enters the dorsal vessel, partly at its posterior extremity, and partly by the lateral orifices already mentioned.

619. It will be observed that, in this course, there is no special conveyance of the nutritious fluid, when rendered venous in its character by circulating through the tissues, to a particular

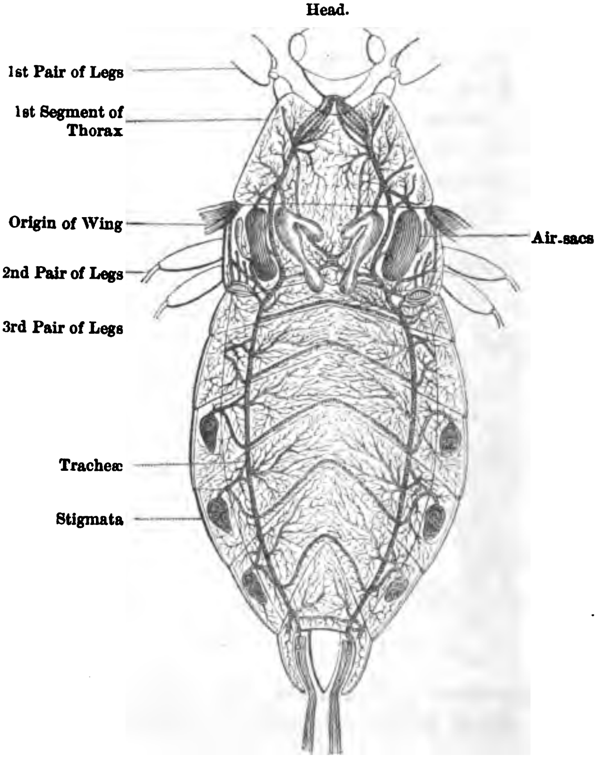


FIG. 326.—RESPIRATORY APPARATUS OF INSECT (NEPA).

organ for its aëration. If the Respiration of Insects were effected in the usual manner, by means of lungs, or at the external surface of the body, it would have been consequently extremely incomplete; but the disadvantage which would appear to be the necessary result of this great imperfection in a function so important as the Circulation, does not really exist. Nature has made up the deficiency in the transmission of the blood, by conducting the air itself into all the parts of the body, by the aid of a multitude of canals, which communicate with the exterior, and which ramify minutely in the substance of the organs. These air-conveying tubes, known, as we have already said, under the name of *tracheæ*, present a very complicated structure: we can usually distinguish in them three coverings, of which the middle one is composed of a cartilaginous filament, rolled in a spiral, like an elastic spring. Sometimes they are simple; but at other times they have a certain number of large dilatations, in the form of soft vesicles, which act as reservoirs of air. The openings by which the air penetrates into the tracheæ are called *stigmata* or *spiracles;* they are generally simple slits, like button-holes; but sometimes they have two valves, which open and shut like the leaves of a folding-door; and they are frequently furnished with a kind of sieve or grating, to prevent particles of dust, &c., being drawn inwards by the air. We usually see one pair upon the lateral and upper part of each segment; but they are often wanting on the two last segments of the thorax. The means by which the air is renewed in the interior of this respiratory apparatus, appears to consist generally only of the movements of contraction and dilatation of the abdomen. As we have already said, Respiration is very active amongst these animals; they consume a considerable quantity of air in comparison with their size, and they quickly die when they are deprived of oxygen; but when they are in this state of apparent death, they may remain in it a very long time, without losing the power of being restored to life.

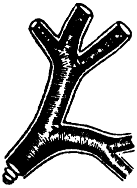


FIG. 327.—AIR-TUBE OF INSECT.

620. The greater number of Insects produce but very little

heat; but some of these animals, in certain circumstances, give out a quantity sufficiently considerable to raise their temperature perceptibly. This is the case with Bees, when they are disturbed in their hives; and it is noticed that their Respiration then becomes very active. (See ANIMAL PHYSIOLOGY, §§ 410, 411.)

621. Another most remarkable phenomenon, of which the cause is not fully known, is the production of *light;* which is observed amongst some Insects. Of this the *Lampyris,* or Glow-worm, is an example, which is well known to almost every one who frequents our fields. The male has wings and is not luminous; but the female, which is destitute of them, and which is often found on banks and hedges during the summer evenings, sheds a phosphorescent light that is often very brilliant. In another species of Lampyris which inhabits Italy, the individuals of both sexes are at the same time winged and luminous; but this singular property is especially remarkable among certain Fire-flies, which live in the warm regions of America, and which produce, when flying in the darkness, a natural illumination of the most brilliant effect; they are often placed by women in their hair as ornaments; and we are told that the Indians use them to light themselves, when they travel by night. Among our Glow-worms, the light proceeds from certain spots situated upon the upper part of the two or three last rings of the abdomen; whilst among the Fire-flies, it comes from analogous spots placed upon the prothorax or corslet. It appears that the insect can vary at pleasure the intensity of this phosphoric light; and that it continues during a certain time, when the animal is placed in a gas unfit for respiration, or even in a vacuum; but that it is extinguished in cold water.

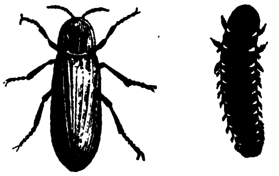


FIG. 328.—MALE AND FEMALE GLOW-WORM.

622. The sexes are distinct amongst these animals, and there often exist very great differences between the male and female;

the common Glow-worm has already afforded us an example of this (Fig. 328). Nearly all Insects lay eggs; some of them are, however, viviparous. There often exists at the extremity of the abdomen of the female, a dart, a saw, or some other organ, fitted to make holes for the reception of the eggs; and by an admirable instinct, the mother always lays them in a place, where her young will find near them the food which they will require; and yet, in the greater number of cases, this food is not the same as she would seek for herself. During the early period of their lives, insects change their skin several times, and nearly always display some very singular phenomena, of which we have already seen an example amongst the Batrachian Reptiles. The greater number of them, at the time of their coming forth from the egg, neither resemble their parents, nor have the form which they will themselves acquire at a later period; and before arriving at a perfect state, they undergo changes so considerable, that we cannot better designate them than under the name of *metamorphoses.*

623. Insects, in general, pass through three very distinct states, known under the names of the *larva state*, the *chrysalis state*, and the *imago* or *perfect state;* but the changes which take place, are not always equally great; sometimes these changes render the animal perfectly different, at other times they only consist in the development of wings; and these various degrees of transformation are known under the names of *complete*, and of *incomplete*, *metamorphosis.*

624. The insects which undergo a *complete metamorphosis*, are always more or less vermiform (or worm-like), when they come from the egg, and when they are in a *larva* state; their body is long, almost entirely soft, and divided into moveable rings, of which the regular number is thirteen. Sometimes they are completely destitute of feet; at other times they are provided with a variable number of these organs; but the conformation of these is not at all analogous to that of the same parts in the adult animal. They have, nearly always, simple eyes, but they are sometimes entirely destitute of them; their mouth is usually fur-

nished with mandibles and jaws, whatever may be the form that it will afterwards assume; and we often see the first of these organs serving for locomotion, as well as for seizing the food.

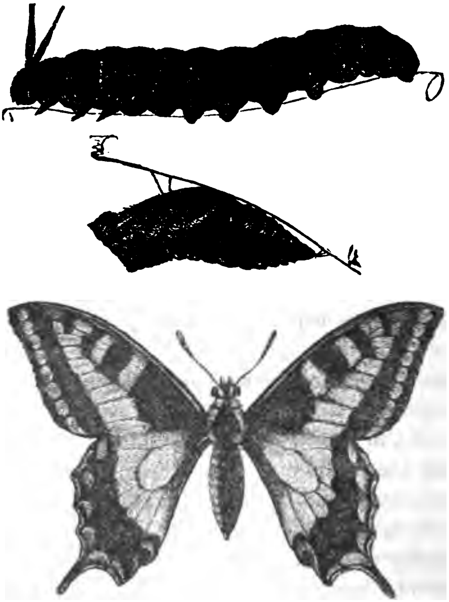


Fig. 329.—Larva, Pupa, and Imago of Papilio Machaon.

These Larvæ also differ in their form, and are sometimes known under the name of *Caterpillars*, sometimes under that of *Worms*. —After having remained in this state for a longer or shorter time, and having experienced several changes of skin, the wings begin to be formed beneath the skin, and the animal passes into the state of *chrysalis*. During the whole length of this second period of their existence, these singular animals cease to take any food, and remain motionless. Sometimes the skin from which they have last freed themselves, dries up, and forms a kind of oval case, in the interior of which they remain shut up; sometimes they are only covered by a thin pellicle, which lies over the external organs, follows all their inequalities of surface, and causes the insect to appear as if closely wrapped in bandages.

625. Before undergoing this metamorphosis, the Larva prepares a defence for itself; and shuts itself up in a case, which it makes with ***silk***, secreted by salivary glands, and drawn out by the aid of ***spinnerets***, hollowed in the lips. In other instances, it suspends itself by means of threads, or conceals itself in some hollow. It is, however, whilst the insect is in this state of apparent repose, that active operations are going on within the body, of which the result is the complete development of the entire organisation. Its interior parts become soft, and by degrees assume the shape that they will preserve; the different organs, with which the adult animal ought to be provided, are developed under the envelope which conceals them; and when this evolution is finished, it frees itself from this species of mask; spreads its wings, which are not long in acquiring firmness, and becomes a ***perfect insect*** or *Imago*.

626. As an example of this complete metamorphosis, we cannot make a better selection, than by taking the *Bombyx Mori*; for this insect in its larva state possesses for us an immense interest; it is the ***silkworm***, the rearing of which contributes so powerfully to the agricultural prosperity of the southern countries of Europe, and the product of which gives origin to so much industry and wealth. This insect came originally from the northern provinces of China, and was not introduced into Europe until the sixth century. The Greek Missionaries brought some of its eggs to Constantinople in the

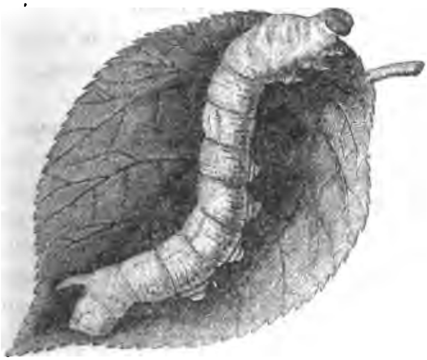


FIG. 330.—SILKWORM.

reign of Justinian, and, at the period of the first crusades, its cultivation was spread into Sicily and Italy; but it was not until the time of Henry IV. that this branch of agricultural industry acquired any importance in the southern provinces of France, of which it now forms one of the chief sources of wealth.

627. The eggs of the Silkworm, when dry, have a gray-ash colour; and with some care they may be preserved thus during a very long time without injury. In order that the work of incubation may commence, and that the larvæ may be hatched, the eggs must be exposed for some time to a temperature of at least 60° Fahr. After having experienced an increasing heat for eight or ten days, they will become whiter; and soon afterwards the larvæ will begin to come forth. These little animals, at the time of their birth, are only about a line and a quarter in length. Their body is long, cylindrical, annular, smooth, and commonly of a grayish colour; at its anterior extremity we distinguish a head, formed by two hard and scaly tubercles, upon which are seen some black points, which are the eyes; the mouth occupies the anterior part of this head, and is armed with strong jaws; the three succeeding rings have each a pair of small scaly feet, and represent the thorax; the abdomen is very much developed, and has no members upon its two first segments, but is furnished at the posterior end with five pair of fleshy tubercles, which resemble stumps, and which serve as so many feet.

628. In the south of France, these worms are called *magnans;* and the name of *Magnanerie* is given to the establishments in which they are reared. The first care that they require after their birth, is to separate them from their shells, and to place them upon frames, on which they find the food adapted for their support. For this purpose it is usual to cover the eggs with a sheet of paper, perforated with holes, through which the worms creep to get at the mulberry leaves placed above; and when they are collected upon the boughs which are covered with these leaves, they are carried away upon the frames prepared for their habitation. The food of the Silkworm consists of Mulberry leaves; and consequently it is on the cultivation of this tree, that the capability of rearing these insects depends. The White

Mulberry is the species the most generally employed for this purpose. It is a tree which grows to the height of fourteen or fifteen feet; it flourishes very well in all soils, and it is cultivated with success even in the north of Europe; but it never grows wild anywhere. The Mulberry came originally from China. Two Greek monks introduced it into Europe towards the middle of the sixth century, at the same time with the Silkworm. Its cultivation was soon spread in the Peloponnesus, and gave to this part of Greece its modern name of *Morea.* Thence the Mulberries and the Silkworms were conveyed into Sicily under the direction of King Roger, and acquired a rapid extension in Calabria. Some French gentlemen who had accompanied Charles VIII. into Italy during the war of 1494, having known all the advantages which that country derived from this branch of agriculture, wished to bestow the same upon their own country; and brought some Mulberry trees from Naples, which they planted in Provence and Dauphiné. About thirty years since, the first of these trees planted in France was still to be seen at Allan, near Montélimart. At present the Mulberry trees cover a large part of the south of France; they are even cultivated in the north; and the success of some recent attempts appears to show, that they might be profitably cultivated in England.

629. Silkworms remain in the larva state for about thirty-four days; and during this time they change their skins four times. The time comprised between these successive changes, constitutes that which the cultivators call the different ages of these little animals. At the approach of each change they become dull and cease eating; but after having cast off the skin, their hunger is increased. The quantity of food which they consume rapidly increases. It is computed that for the larvæ proceeding from an ounce of eggs, there must be generally about seven pounds of leaves during the first age, which lasts five days; twenty-one pounds during the second period, which only continues four days; seventy pounds during the third period, which continues seven days; two hundred and ten pounds during the fourth age, whose length is the same as that of the third age;

and twelve or thirteen hundred pounds during the fifth period. It is on the sixth day of the last age, that the greatest voracity shows itself. The worms then devour two or three hundred pounds of leaves, and when eating make a noise which resembles that of a heavy shower. On the tenth day they cease eating, and prepare themselves to undergo their first metamorphosis. We then see them endeavouring to climb upon the branches of small bundles of twigs, which have been carefully placed above the frames on which they have until then remained. Their body becomes soft, and a thread of silk comes out of their mouth, which they draw after them. They very soon fix themselves, and throw around them a multitude of threads of extreme fineness; and, suspended in the middle of this net-work, spin their Cocoon, which they form by continually turning themselves round in different directions—thus twisting round their body the thread which comes out from the spinneret, with which the lip is perforated. The silk, thus formed, is produced in glands, which have much analogy with the salivary glands of other animals; and the matter of which it is composed is soft and glutinous at the time of its first appearance, but soon becomes hardened by the air. The result of the different twistings of this single thread, is to cause the different threads to adhere together, and to form an envelope, whose tissue is firm and shape oval. The colour of the silk varies; sometimes it is yellow, sometimes of a brilliant white, according to the variety of the worm which has produced it; and the length of each thread often exceeds 1100 feet, but varies much, as does also the weight of the cocoons. The worms proceeding from an ounce of eggs may produce as much as 130 lbs. of silk; but such an amount is rare; and from 70 to 80 lbs. is the usual product.

630. In general, three days and a half or four days are sufficient for the larva to finish its Cocoon; and if we then open this envelope, we see that the animal no longer presents the same appearance as before its seclusion. It has become of a brownish colour, its skin resembles old leather, and its shape is oval, a little pointed at its posterior extremity. We no longer distinguish a head or jaws; but the posterior extremity is formed by

two moveable rings, whilst in front we see an oblique band, representing the future wings of the perfect animal. The time during which the Bombyx remains thus shut up in a Chrysalis state, varies according to the temperature. If the heat is from 60 to 65 degrees, they come out of it in a perfect state on the eighteenth or twentieth day. In order to open the Cocoon, they moisten it at one extremity with a particular liquid, which they throw up from the stomach; and then they violently strike their head against the part thus softened. When the Bombyx has thus finished its metamorphosis, it presents itself under the form of a Moth, with whitish wings; its mouth is no longer furnished with jaws, as in its early state, but is prolonged into a rounded spiral trunk; its legs are slender and lengthened, and its internal conformation differs as much from that of the Larva, as its external form. Almost immediately after this second birth, the Moths seek each other for the purpose of reproduction; and the females subsequently deposit their eggs, of which the number sometimes amounts to more than five hundred for each of these insects; and at last, after having lived in a perfect state for ten or twenty days, during which time they take no food, they die.

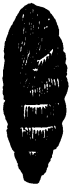


FIG. 331.—CHRYSALIS OF THE SILKWORM.

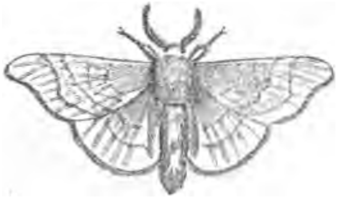


FIG. 332.—SILKWORM MOTH.

631. Among Bees we meet with still greater changes; since in their Larva state they are completely destitute of legs, and resemble small worms. It is the same with Flies, Gnats, and a great number of other insects; thus the vermiform animals which swarm in putrid carrion, and which are known under the name of Maggots, are nothing else than the larvæ of the Meat-fly. The Gnats or Musquitoes, which fly in such large swarms, and

which render themselves so unpleasant to Man by their venomous punctures, live in the water during their larva state. They are then vermiform, destitute of limbs, and have the abdomen terminated by bristles and some appendages arranged in a radiated form (Fig. 333); and from their last ring arises a long tube, by the aid of which the animal draws in from the atmosphere the air which it requires. To breathe by this means, it suspends itself as it were from the surface of the water, with its head downwards; and we see it performing this movement at short intervals. The Chrysalis continues to live in the water, and to move about there; but instead of breathing like the larvæ, it draws in the air which it requires by means of two pipes, placed upon the thorax. It floats on the surface of the liquid; and after having completed its metamorphosis, the perfect insect uses the skin of the chrysalis as a boat, until its long legs and wings have gained sufficient strength to enable it to move on the surface of the water, or to fly away; but if its body happens to be submerged, as often occurs when the wind upsets these frail barks, it is infallibly drowned.

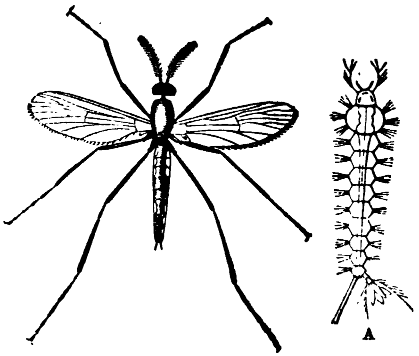


Fig. 333.—Gnat and Larva.

632. The Insects with incomplete metamorphosis also pass through the larva and chrysalis state, before arriving at the perfect state; but here the larva only differs from the perfect insect by the absence of wings; and the state of the chrysalis is only characterised by the gradual development of the wings, which, at first folded back and concealed under the skin, then become free; but only acquire their full development at the period of the last change. We may mention, as examples of

insects showing this kind of metamorphosis, the Grasshopper and the Ephemeræ or Day-flies. These last display a remarkable peculiarity; since in general, insects change the skin for the last time, when they pass from the Chrysalis to the perfect state; whilst the Ephemera experiences one more change, before arriving at its complete form, in which it only lives for the space of a few hours. The larva of the Ephemera lives in the water, and differs very little from the adult, except in the shortness of its limbs, the absence of wings, and by the row of leaf-like appendages which it bears on each side of its abdomen, and which it uses as organs of respiration and of motion in the water. The chrysalis only differs from the larva, by the presence of cases inclosing the wings. At the time when these organs should be developed, the insect comes out of the water; and after having fluttered about during some minutes, it takes its place upon an elevated object, and there performs some violent movements, by means of which it casts away its enveloping membrane; it is then only that its limbs attain their full length, and that the body acquires the colours which it will preserve.

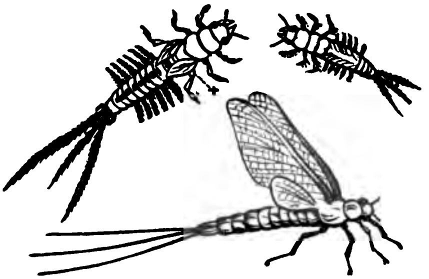


FIG. 334.—EPHEMERA VULGATA: LARVA, PUPA, AND IMAGO.

633. Some Insects, although undergoing considerable changes at an early period, do not pass through the complete series of transformations of which we have first spoken; they appear to stop short in their development, never possessing any wings. The Fleas are thus circumstanced. When they come forth from the egg, they are destitute of feet, and have the form of small worms of a whitish colour. These larvæ are very active, and roll themselves in a circle or a spiral. They soon become of a reddish hue; and after having lived in this condition during

twelve days, they shut themselves up in a small silky shell, of extreme delicacy, and are there transformed into a chrysalis; at the end of about twelve days of seclusion, if the weather is warm, they come out of their envelope in a perfect state.

634. Again, there are some Insects which do not pass through any metamorphosis, and which are born with all the organs with which they will ever be provided; but it is only among *Apterous*, or wingless, Insects, that this mode of development exists. The Podura, which has been already referred to, and the Louse, are of this kind.

635. The class of Insects, which (as we have seen) is so remarkable for its organisation, is still more so in regard to the habits of the animals composing it, and the admirable instincts with which Nature has endowed a great number of them. The stratagems which they employ to procure themselves food, or to escape from their enemies, and the industry which they display in their labours, astonish all those who are witnesses of it; and when we see them unite themselves into numerous societies, to make up for their individual weakness, helping each other by dividing the labour necessary for the prosperity of the community, providing for their future wants, and often even regulating their actions according to the accidental circumstances in which they find themselves placed, we are confounded at encountering amongst beings so small, and in appearance so imperfect, instincts so varied and so powerful, and intellectual combinations which so much resemble those of the reasoning powers. This subject will be more fully treated of in the latter part of the present volume. At present we must confine ourselves to a sketch of the classification of this group; which, on account of the immense number of forms included in it, must be more slight than that which has been given of the preceding classes.

636. The subdivision of the Class into Orders is founded chiefly upon the structure of the Mouth, the conformation of the Wings, and the nature of the Metamorphosis. Neither of these characters must be trusted to singly; since within the limits of one group, we find considerable variation. Thus in almost every order, we meet with *apterous* or *wingless* insects; an example of

which we have already seen in the Glow-worm. Sometimes, as in that instance, the deficiency of wings is confined to one of the sexes—usually the female; whilst in other cases, both sexes are destitute of these organs. Nevertheless there is a group, consisting of three small orders, in which the want of wings is the rule and not the exception; and the insects brought together in these, are associated together on account of their resemblance to each other in general structure;—whilst, on the other hand, the wingless insects first alluded to are left among the orders in which they are placed, on account of their correspondence with other insects of those orders in the structure of the mouth, the nature of the metamorphosis, &c.

637. We may divide the Class into two Sub-classes; the members of the first of which (A) always undergo some degree of metamorphosis, and are usually possessed of wings in the perfect state; whilst those of the second (B) undergo no metamorphosis, and never become possessed of wings.—From the first sub-class may be separated one order, in which there are no wings; and there then remain *eight* principal orders, which are classed according to the structure of the mouth and wings.

SUB-CLASS A.

Division *a.*—Winged insects undergoing metamorphosis.

Order I. COLEOPTERA (*Beetles*). In these the mouth is formed for mastication; the anterior wings are converted into hard *elytra*, or wing-cases; the posterior wings are folded transversely (or cross-wise) during repose; and the metamorphosis is complete.

Order II. ORTHOPTERA (*Grasshopper*, *Locust*, *&c.*). In these also the mouth is formed for mastication; the anterior pair of wings is composed of a substance more resembling parchment; the posterior pair, when in repose, is folded longitudinally (or lengthwise) in the manner of a fan (Fig. 369); and the metamorphosis is incomplete.

Order III. NEUROPTERA (*Dragon-fly*, *May-fly*). In these, too, the mouth is formed for mastication; but the anterior pair of wings, like the posterior, is membranous; and the nerves of the wings form a close reticulation or network by their interlacement. The degree of metamorphosis is variable.

Order IV. HYMENOPTERA (*Bee, Wasp, Saw-fly*). In these, the mouth is still furnished, as in the preceding, with prehensile mandibles, but the other parts are so formed as to be rather fitted for suction than for mastication; the wings are all membranous, but the nerves do not form such a minute reticulation as in the preceding order; the metamorphosis is always complete.

The four preceding orders, in which *mandibles* are always distinctly present, form the group of MANDIBULATA; the four succeeding, in which the mandibles are wanting or are completely changed in form, and in which the other parts are adapted for suction, being converted into a more or less complete *haustellium* or sucking-tube, are termed HAUSTELLATA.

Order V. HOMOPTERA (*Cicada, Lantern-fly*). In this order, the four wings are of the same consistence, and are rather firmer than usual, being often somewhat parchmenty in texture; when folded, they incline at an angle, like the roof of a house.

Order VI. HETEROPTERA (*Bugs, Boat-flies*). The consistence of the two pairs of wings is here different, the anterior pair of wings being of a horny or parchmenty consistence (though generally tipped with membrane), whilst the posterior are simply membranous; when folded, they are horizontal, or but slightly inclined, and sometimes lap over each other.

Order VII. LEPIDOPTERA (*Butterflies and Moths*). These have the mouth furnished with a long trunk, coiled in a spiral when not in use; the wings are all membranous, and are covered with minute scales, having the appearance of fine dust, but arranged with the most perfect regularity; the metamorphosis is complete.

Order VIII. DIPTERA (*Gnats, Flies, &c.*) In these there are but two wings; the mouth is furnished with a sucking-tube; and the metamorphosis is complete, or nearly so.

Division *b*. Insects undergoing metamorphosis, but destitute of wings. This division includes but a single order.

Order IX. APHANIPTERA (*Flea, &c.*) In this group, also, the mouth is formed for suction; and the insects composing it are parasitic, living upon the juices of other animals.

SUB-CLASS B.

The small remaining section, consisting of Insects which undergo no metamorphosis, and are destitute of wings, includes two orders.

Order X. ANOPLOURA (*Louse*). These are distinguished from the succeeding, by the absence of appendages to the abdomen.

Order XI. THYSANOURA (*Spring-tails, &c.*) In these the abdomen is furnished with false legs, or appendages, adapted for leaping.

Besides these principal groups, there are some small intermediate orders, by which the former are connected. These are not admitted, however, by all Entomologists. Thus the *Earwig* tribe, which combines, in some degree, the characters of the Coleoptera and Orthoptera, is raised by many to the rank of a distinct order—DERMAPTERA, which leads from the first to the second order. Again, a separate order—TRICHOPTERA, has been formed to include the *Caddice-flies*, which are intermediate between the Lepidoptera and Neuroptera. And, lastly, there is a small order—STREPSIPTERA, or RHIPIPTERA, which includes a small group termed *Wasp-flies*, intermediate, in several respects, between the Hymenoptera and Diptera, but differing from both in so many particulars, as apparently to require being arranged by themselves.

ORDER I.—COLEOPTERA, OR BEETLES.

638. The insects composing this Order, all of which are known under the common name of *Beetles*, are the most numerous and best known of the whole class. The singular forms and brilliant colours exhibited by many of the species, the size of their bodies, the solid texture of their integuments, which facilitates their preservation, and the nature of their habits, which makes their capture more easy, have combined to render them an object of peculiar attention to Entomologists, many of whom have devoted themselves to this order exclusively. It is probable that from 30,000 to 40,000 species of Beetles alone now exist in

the cabinets of collectors; and we may safely affirm, that at least as many more yet remain to be discovered.

639. The conversion of the first pair of wings into *elytra*, or hard wing-cases, and the complete inclosure of the second pair by these, when the insect is at rest, constitute, as we have seen, the distinguishing features of the Order. The elytra, when expanded, are of little or no use in flight, generally remaining nearly motionless; when closed, they meet along the back in a straight line, which is called the *suture*. The structure of the mouth, in this order, has been already described. The head is provided with two antennæ, which vary in form, but which have usually eleven joints; the form of these often differs considerably in the two sexes. The eyes are large and protuberant, especially in the carnivorous species, and in those, the slowness of whose habits makes them need quick powers of sight, for the purpose of avoiding their enemies. Of the three segments of the thorax, the anterior one (commonly termed the corslet) greatly surpasses the two others in size; being so much developed at their expense, as almost to constitute the thorax by itself. The two latter segments are firmly united to each other, and to the commencement of the abdomen; and the chief movement of the parts of the trunk upon one another, is between the first and second segments of the thorax; the latter being prolonged forwards into a sort of footstalk, which is received into a cavity in the former, and thus serves as a kind of pivot for its movements. The abdomen usually consists of only six or seven segments; the remainder of the nine, which properly form this part, being consolidated in the last.

640. Although the characters already mentioned are applicable to by far the greater number of insects included in this Order, nearly all of them are subject to exceptions. Thus, there are many species, in which the organs of flight seem altogether wanting, in one sex, at least, as in the female Glow-worm; even here, however, the rudiments of elytra will be found. In other instances, the elytra are fully developed, so as to cover the upper surface of the body; but adhere together along the suture, so as to prevent the expansion of the wings, which are, consequently,

never developed; this is the case in the *Blaps* (Fig. 349). In other cases, again, the elytra, instead of simply meeting along the suture, fold over each other; in other instances, they do not meet at all; and there are some species in which the wings are folded, not *transversely*, but *longitudinally*, as in the next order. It is well for the Student to be aware that such exceptions exist in this, as in every other large natural group; however definite its characters may generally be. In none of these instances, is there an exception as to more than one or two of the characters in question; the remainder conform to the usual type.

641. The Metamorphosis in this Order is invariably *complete;* and it is thus distinguished from all that approach it in the structure of its mouth, or in the character of the wings. The *larvæ* are worm-like in their aspect; the head is usually horny, the rest of the body soft. There is generally a pair of short jointed legs attached to each of the first three segments, bearing some resemblance to those of the perfect insect. Those which possess legs are usually active in their habits; but there are others which, leading a retired life, and being born in the midst of their food (such as the Nut Weevil), are destitute of members. The larvæ of the carnivorous species have in general the most robust legs; and in some of the herbivorous species these are replaced by fleshy tubercles, or *pro-legs.* A pair of these generally exists on the last segment

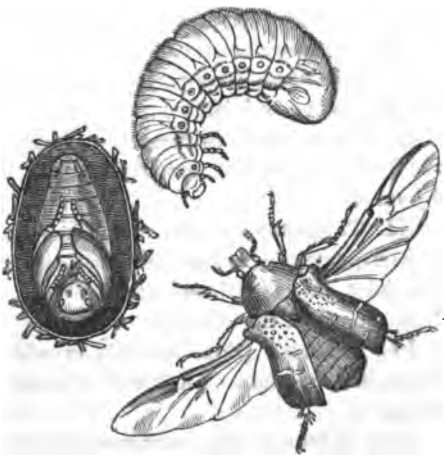


FIG. 335.—LARVA, PUPA, AND PERFECT STATES OF CETONIA AURATA, OR ROSE-BEETLE.

of the abdomen. Previously to undergoing its change, the larva often forms a case for itself, of bits of earth, or chips of wood, united by silken threads, or by gluey matter. The *pupa*, or chrysalis, is inactive, sometimes even for years, and takes no nourishment; but the form of the future Beetle is plainly perceived, the different parts being encased in distinct sheaths. (Fig. 335).

642. There is much difficulty in forming a simple natural classification of this immense tribe, on account of the great number of distinct species which it includes, and their strong general resemblance to each other. Hence it is often necessary to resort to characters of great minuteness as the ground-work of the system; and it sometimes happens that, by the adoption of such a plan, tribes which are in reality closely allied in general structure, are placed in different groups, whilst others are brought together which are in many respects dissimilar. No better system, however, has yet been proposed than that of Latreille; who took as the basis of his classification the number of joints in the *tarsus* or last portion of the foot (§ 607). The four following sections are thus formed.

I. Pentamera (five-parted), in which the tarsi of all the feet are distinctly 5-jointed.

II. Heteromera (differently-parted), in which the tarsi of the first two pairs of feet are 5-jointed, and the two posterior 4-jointed.

III. Tetramera (four-parted), in which all the tarsi appear to be 4-jointed. (It has lately been observed, however, that the fifth joint exists in these, although it is very minute, and concealed in one of the others.)

IV. Trimera (three-parted), in which all the tarsi have three distinct joints. (A fourth of small size, however, is also present.)

Each of these sections contains several families; of which the most important will now be noticed.

643. Section I. Pentamera. The first family of this section consists of Beetles which are exclusively carnivorous; hunting after, and devouring, other insects; and being carnivorous

even in their larva state. These CARNIVORA are characterised by the possession of six palpi,—there being two to each of the maxillæ (Fig. 315),—and by the termination of the jaws in a sort of claw or hook. Some of them are *terrestrial*, and others *aquatic;* in the former, the legs are adapted only for running; in the latter, they are modified for swimming.—The terrestrial division of the family is composed of two very large tribes, the *Cicindelidæ* and the *Carabidæ*, characterised chiefly by the form and mode of attachment of the hook at the end of the jaws. The *Cicindelidæ* have the body usually of a dark or light-green colour, varied with shining metallic tints, and with white spots upon the elytra; they frequent dry situations exposed to the sun, run very quickly, fly off when they are approached, and alight again at a short distance. The larvæ burrow in the earth, forming a cylindrical hole of considerable depth; in the process of excavation they use their jaws and feet, and load the concave back of their heads with the grains of earth which they have detached; thus loaded, they ascend backwards, resting at intervals, and fixing themselves to the inner walls of their burrow by the assistance of two hooked tubercles on the back; when arrived at the orifice, they jerk off their load to a distance. Whilst lying in ambush, the flat plate of the head exactly stops the mouth of the hole, forming a flat surface with the surrounding soil. When their prey comes within their reach, they rush upon it with great ferocity, and seize it between their powerful jaws; and their voracity is even extended to larvæ of the same kind. They close the orifice of their burrow when they change their skin, or undergo their metamorphosis into the pupa state. There are several British species of this group; as well as a large number of brilliantly-coloured tropical species, of which many are apterous.

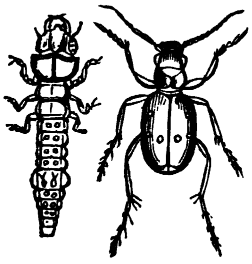


FIG. 336.—CICINDELA CAMPESTRIS, AND LARVA.

644. The tribe of *Carabidæ* is of very great extent; above

2000 species having been brought together by a single collector. Their bodies are of very firm consistence, whereby they are enabled to creep under stones and through fissures, and are also prevented from being injured by the insects they attack. They prowl about on the surface of the ground, under stones, &c., beneath the bark of trees, or the moss growing at their roots, in search of their insect prey, which consists chiefly of the herbivorous species of their own order. Some of them are nocturnal in their habits, feeding upon Cockchafers and other species of herbivorous beetles that fly abroad during the night. The habits of this tribe are not exclusively carnivorous, however, for some species, generally found in corn fields, are clearly ascertained to feed upon growing grain.—Many species of this tribe are provided with a very curious means of defence; being enabled to exhale a very fetid odour, and to discharge from the abdomen, to a considerable distance, an acrid fluid, capable of producing much irritation. In the *Brachinus* this fluid is so highly volatile, that, immediately on coming in contact with the air, it passes into a bluish vapour of very pungent scent, and makes a sort of explosion; hence the species possessed of this power have been termed *Bombardier* Beetles. The larger species are found only in tropical regions; but the small species represented in the accompanying figure, is a native of England. The Bombardier Beetles for the most part live in societies, especially in spring; and are found concealed under stones. Of the entire family, a considerable proportion are found in Britain and other temperate countries; but the largest and most brightly-coloured species are confined to warmer climates.

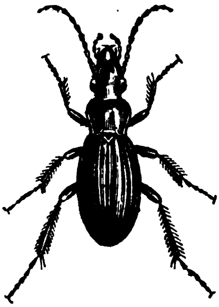


FIG. 337.—CARABUS.

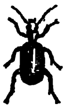


FIG. 338.—BOMBARDIER BEETLE.

645. The *aquatic* Carnivora form a tribe far less numerous than the terrestrial species; and are at once distinguished by the peculiar modification of the legs, which adapts them for swimming,

—these members being flattened, and fringed with bristles, so as to serve as oars. They live, during their larva and perfect states, in water; but they quit that element to undergo their metamorphoses, and to pass the time of their pupa condition. The larvæ have the body long and narrow, with a strong head armed with powerful mandibles; and they are of very active carnivorous habits. They breathe by organs adapted for aquatic respiration; but the perfect insects can only breathe air, and are obliged to come to the surface occasionally for that purpose. The *Dytiscus*, the principal genus of this tribe, is common in fresh and placid waters, such as lakes, pools, or ditches. Its larva feeds upon other aquatic larvæ, such as those of dragon-flies, gnats, &c.; and moves quickly through the water, by means of strokes with its expanded tail. The pupæ may be found buried in the adjoining banks. The Imago also is very voracious, feeding principally upon the juices of the animals it attacks, which are often much larger than itself; an individual has been kept in a large bottle of water for three years and a half, being fed once a week or oftener with a bit of raw beef, from which it extracted the blood, but being able to fast for a month at a time.—The other principal genus is the *Gyrinus* (Fig. 299), the common species of which are known under the name of "Whirligigs," from their peculiar motion. These may be met with, from the first fine days of spring until the end of autumn, on the surface of quiet waters, and even upon that of the sea, often assembled in great numbers, and appearing like brilliant points. They swim with great agility, often curveting in a circular direction,—whence their common name. Sometimes they remain stationary without the slightest motion; but no sooner are they approached, than they escape by darting under the surface of the water, and

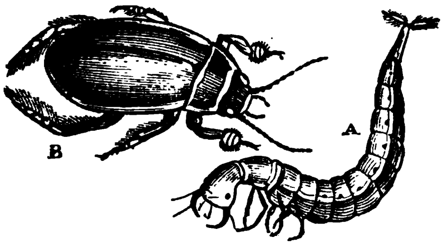


FIG. 339.—DYTISCUS MARGINALIS AND LARVA.

swimming off with the greatest agility. The four hind-legs are used as oars, and the anterior pair for seizing the prey. When they dart beneath the surface, a bubble of air, like a silvery ball, remains attached to the hind part of the body.—Numerous species of both these genera are found in Britain.

646. The next family of the Pentamerous Beetles is that of BRACHELYTRA, distinguished, as the name imports, by the shortness of the *elytra;* these, which have only four palpi, contain but a single tribe, composed of the genus *Staphylinus* and its allies. These insects run and fly with equal agility; they are extremely voracious; but do not feed on living prey, deriving their nutriment from dead and decaying animal and vegetable matters. The majority live in the earth, amidst manure and putrescent substances; others are found among Fungi and rotten wood, and under stones; others, again, are only met with near water; and a few of the smallest are only found in flowers. The larvæ feed on the same substances, and in the same situations, as the perfect insects; and greatly resemble them in form. These Beetles,—of which one of the largest is frequently to be seen running about garden-walks, and is commonly known under the name of the Devil's Coach-horse,—turn up the end of the body when touched, bending it in all directions; and they possess the power of emitting a strong odour, which is in some instances extremely fetid, and which serves as a means of defence.

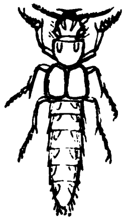


FIG. 340.—STAPHYLINUS ERYTHROPTERUS.

647. The next family, SERRICORNES, is distinguished by the toothed or serrated form of the antennæ. As in the preceding, there are only four palpi; but the elytra completely cover the body. Some of this family, having the body of solid consistence, and oval in form, have the head buried, as it were, in the thorax, which advances on its two sides, nearly as far as the mouth. In this manner is formed the *Buprestis*, distinguished for the splendour of its colours; many of its species having spots of golden hue upon an emerald ground; whilst in others, azure glitters upon the gold. The largest and most brilliant species

are found chiefly in tropical climates, which these insects appear especially formed to inhabit; our native species, which are not above a quarter of an inch long, being observed to fly with the greatest activity in warm weather. They live among trees; and, if an effort be made to seize them, they counterfeit death, and fall to the ground.—The Beetles belonging to the allied genus, *Elater*, are commonly called Skip-jacks; for, when laid on their backs, being unable to raise themselves on account of the shortness of their legs, they spring perpendicularly in the air, so as to alight upon their feet. This is effected by first bending the head and anterior portion of the thorax towards the abdomen, and then violently straightening it, so as to give a backward stroke against the surface on which they are lying. The larva of one of the British species, known to the farmer as the Wire-worm, does much injury by devouring the roots of the corn. A species of Elater, inhabiting the West Indies and South America, is one of the most brilliant of the Fire-flies; having two brightly-illuminated spots upon the front of the thorax, and a portion of the abdomen which is uncovered during flight being also very luminous.—Nearly allied to the Elaters is the *Lampyris* or Glow-worm tribe; of which sufficient mention has been already made. —To the same very numerous family belong the genus *Ptinus* and its allies; one species of which is well known under the name of Death-watch. These are insects of small size and slow movements; many of them are destitute of wings; and those which possess them seldom use them as means of escape. When touched, they counterfeit death by lowering the head, drawing in the antennæ, and contracting their feet; and they remain in this position for some time. Their colours are always obscure, and but slightly variegated; and they live in dark places near or upon the surface of the ground. Of the sub-genus, *Anobium*, many species inhabit the interior of our houses, where they do much injury in the larva state, by gnawing furniture,

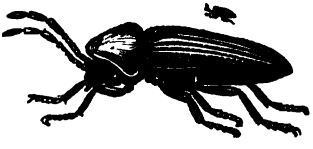


FIG. 341.—ANOBIUM STRIATUM, NATURAL SIZE AND MAGNIFIED.

books, &c., which they pierce with little round holes, like those made by a drill. Other species feed upon flowers, wafers, preserved specimens of natural history, &c. The curious sound made by them—from which have arisen the superstitious ideas that gave origin to their common name,—has been elsewhere noticed (ANIM. PHYSIOL. § 677). The species is remarkable for the pertinacity with which it feigns death when alarmed; preferring, it is said, to suffer death under a slow fire, rather than give the least sign of life.

648. The succeeding family, that of CLAVICORNES, consists of those Pentamerous Beetles, whose antennæ end in a club-shaped enlargement. These are partly terrestrial, and partly aquatic. They feed for the most part on animal matter, at least in the larva state; but a large proportion of them prefer substances which are in a decaying or putrescent condition. One of the most interesting genera is the *Necrophorus* or *Burying Beetle*; so named from its habit of excavating the ground beneath the dead bodies of small quadrupeds, such as Mice or Moles; when they have interred the carcass, they deposit their eggs in it, and the larvæ, when hatched, feed upon the flesh.—Another genus, which includes a large number of species, is the *Dermestes*; of which the larvæ (whose bodies are hairy) are very voracious, feeding on the skins or carcasses of animals, often destroying collections of insects, and committing great ravages in fur-warehouses.

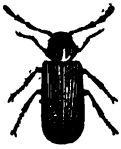


FIG. 342.—DERMESTES.

649. The PALPICORNES also possess antennæ with a club-like termination; but these are never longer, and are usually shorter, than one of the pairs of palpi. Nearly all of them are aquatic, and have their legs adapted for swimming, somewhat in the manner of those of the Dytiscus. The most remarkable genus is the *Hydrophilus*, of which one large species, an inch and a half long, oval, of a brown-black colour, and highly polished, is common in the ponds and ditches of this country. It swims and flies well, but walks badly. The eggs are laid in a sort of cocoon, spun by the female, and coated with a gummy matter that is

impervious to the water on which it floats. The larvæ, which have a worm-like body, with six feet, and with sharp mandibles arming the head, are very voracious; feeding upon Tadpoles and the young fry in fish-ponds, and upon small fresh-water Mollusca.

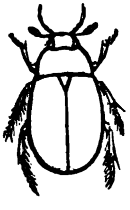


FIG. 343.
HYDROPHILUS.

650. The last family of the Pentamerous section, the LAMELLICORNES, is of very great extent, as well as one of the most striking of the whole Beetle tribe, in regard to the size of the body, and the variety in the form of the head and thorax in the different sexes; and also, moreover, in those species which in their perfect state live upon fresh vegetable substances, in respect to the brilliancy of the metallic colours with which they are ornamented. But the majority of other species, which subsist on decomposing vegetable matter, are of an uniform brown or black colour; although some are not inferior in brilliancy to the preceding. All have wings; and they crawl but slowly along the ground. None of them are aquatic. Their food consists of dung, manure, tan, and particularly, in some species, of the roots of vegetables; whence these insects, in their larva state especially (this being always the period of greatest voracity), often occasion great loss to the cultivator.—This family receives its name from the peculiar conformation of the antennæ, which terminate in a mass formed of the last three joints; these are flattened into plates or lamellæ, and are sometimes arranged like a fan or the leaves of a book, sometimes in the manner of a comb, and sometimes inclosing one another. The family is divided into two principal sections, the *Scarabæi* and the *Lucani*.

651. Of the *Scarabæi*, one subdivision, including the sacred Beetle of the Egyptians (Fig. 344), feed principally upon the excrements of various animals; and they inclose their eggs in balls of the same (whence they have been called Pilularii), which they roll along with their hind feet, several often being in company, until they reach the hole in which these are to be deposited. Of these we have a characteristic example among British species, in the *Geotrupes stercorarius*, the

common Dor or Shard-borne Beetle; which is one of the commonest of all Beetles in this country. One of the most remarkable amongst foreign species is the *Dynastes Hercules*, a native of Brazil, which attains the length of 5 inches, and of which the male possesses an enormous horn projecting from the head, which is opposed by a corresponding protuberance from the thorax. To this group also belongs the *Melolontha vulgaris* or common Cockchafer; which is most destructive to vegetation in both its larva and perfect conditions, feeding on the roots in the one case, and on the leaves and young shoots in the other. The larvæ live for three or four years beneath the ground; becoming lethargic in winter, but actively voracious in summer. Their excessive multiplication is usually prevented by birds; but if these be kept away, they increase very rapidly, and become a complete pest to the cultivator. The perfect insects sometimes make their appearance in such swarms, as to

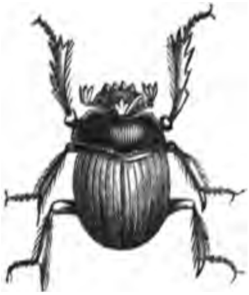


FIG. 344.—ATEUCHUS (SCARABÆUS) ÆGYPTIORUM.

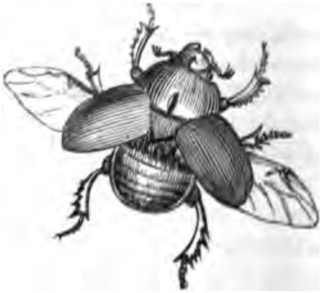


FIG. 345.—GEOTRUPES STERCORARIUS.

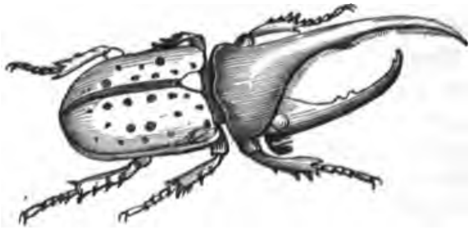


FIG. 346.—DYNASTES HERCULES.

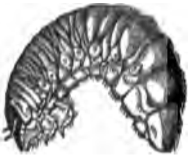


FIG. 347.—LARVA OF COCKCHAFER.

devastate an entire forest. To this group also belongs the *Cetonia aurata* or Rose-beetle, a very common British insect, of which a figure has been already given (Fig. 335); it is about an inch long, of a shining-green colour above, coppery-red beneath, with white marks on the elytra. In its larva state, it frequents rotten timber and wood, and is often met with underground in ants' nests, where it would seem to feed upon the bits of wood of which they are composed; from this circumstance it is sometimes called the "king of the ants." After remaining about three years in the larva state, it makes a sort of cocoon of chips of wood, glued together by an excretion of its own; in this it passes the winter in the state of an inactive pupa, from which it emerges in the following summer in its perfect form. The Rose-beetle flies well, with a considerable humming noise, during the hottest part of the day; and goes from flower to flower (not confining itself to Roses, but seeming to prefer them), sucking the honey from their interior, and sometimes devouring their nectaries.

652. The *Lucani*, or Stag-Beetles, derive their common name from the peculiar form of the mandibles, which are very large, curved, and toothed, like stags' horns (Fig. 316). The *Lucanus cervus*, a highly-characteristic species of the group, is one of the largest of British insects, the males being two inches or more in length. This species flies about in the evening, in the middle of summer, especially round the oaks, upon the wood of which the larva feeds; remaining in that state for several years, before undergoing its final transformation. The accompanying figure represents the *Dorcus parallelipipedus*, or Small Stag-Beetle of this country; which is far less striking than the larger species in regard to the development of its maxillæ. Some of the exotic species of this group are very large and splendidly coloured.

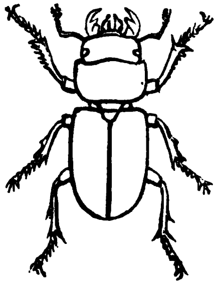


FIG. 348.—DORCUS PARALLELIPIPEDUS.

653. Section II. HETEROMERA. The Coleoptera of the Second section, characterised by possessing five joints in the tarsi of the two anterior

pairs of feet, and of only four in the posterior tarsi, entirely feed on vegetable substances; they are all terrestrial, and most of them frequent dark places.—In the first family, the **MELASOMA** or *black-bodied* Beetles, the body is usually of an ashy-brown or black colour; and the wings are for the most part absent, the elytra being united along the suture. They usually live in the ground, beneath stones, or in the sand—often also in low and dark parts of buildings, such as cellars, stables, &c. The insects of this tribe are very tenacious of life; individuals having been known to remain alive for six months without food, and pierced through with a pin. To this family belong the *Blaps mortisaga*, a beetle often found in dark and dirty places about houses; and the *Tenebrio molitor*, of which the larva, known under the name of the *meal-worm*, lives in corn and flour, whilst the perfect insect also frequents bake-houses, corn-mills, &c., where it may be often found in the eaves.

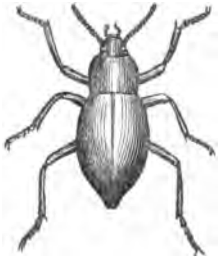


FIG. 349.—BLAPS MORTISAGA.

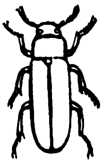


FIG. 350. TENEBRIO MOLITOR.

654. We may pass over the families of **TAXICORNES** and **STENELYTRA**, as presenting no points of special interest, to notice the **TRACHELIDES** (*necked*-beetles), so named from having the head, which is triangular or heart-shaped, carried on a kind of neck, which separates it from the thorax. The body is soft; and the elytra are flexible, and sometimes very soft. The majority of this group live in the perfect state upon different vegetables, devouring the leaves, or sucking the juices of the flowers.—Many of them, when seized, depress the head and contract the feet, as if they were dead. Their colours are often very brilliant. This is well seen in the *Cantharis vesicatoria*, commonly known

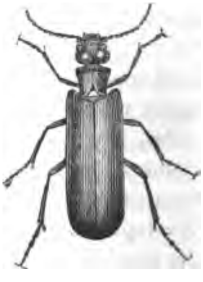


FIG. 351.—CANTHARIS VESICATORIA.

as the Blistering-fly, which is of a shining green metallic hue; this insect is most abundant in Spain, but appears about midsummer in France, and is found in great numbers on the ash and lilac, of which it consumes the leaves. Its larva lives in the earth, and feeds upon the roots of vegetables.

655. Section III. **Tetramera.** All the Beetles of this group, likewise,—consisting of those which have four joints in all the tarsi,—are vegetable-feeders. The perfect insect is found upon the flowers and leaves of plants; the larvæ are often produced in their interior; and, when thus hatched in the midst of their food, their legs are commonly very imperfect. Very often the true legs are almost entirely absent, and their place supplied by fleshy tubercles. The first family, that of **Rhyncophoræ**, or the *Weevil* tribe, is distinguished by the prolongation of the anterior part of the head into a kind of muzzle (Fig. 352, D). The number of species in this family is very great; nearly four thousand have been already collected. Many of them are extremely destructive; especially the *Calandra granaria*, which commits great havoc in granaries, both in its larva and perfect states. The accompanying figure exhibits the history of the development of the *Balaninus nucum*, or Nut-Weevil, whose larva is so commonly found in nuts, filberts, &c. The egg is introduced by the parent when the nut is young and soft; and the wound made by it heals over. The larva, when it comes forth from the egg, feeds upon the kernel in which it is imbedded; and, when about to change its state, it bores through the shell, and escapes, leaving

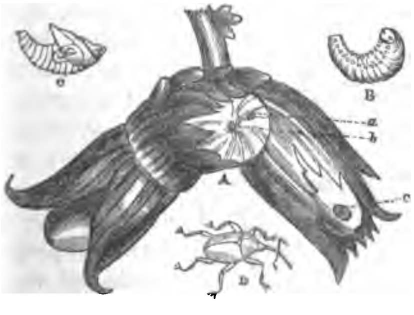


Fig. 352.—A, a branch of the filbert tree; *a*, a healed wound caused by the introduction of the egg of the nut-weevil; *b*, extremity of the nut; *c*, exit hole of the grub; B, the grub of the nut-weevil; c, the pupa of the same; D, the perfect insect (*Balaninus nucum*).

a small round orifice. To this tribe belongs one of the most splendid of all Beetles, the *Curculio imperialis*, well known as the Diamond-beetle, which is a native of South America, and very abundant in some parts of that country. There are small species belonging to our own island, however, which are scarcely less brilliant when magnified under a good light.

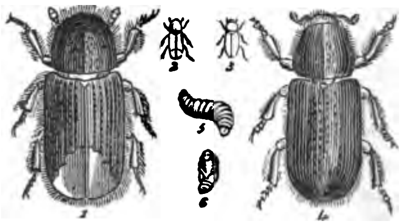


FIG. 353.—1, 2, TOMICUS TYPOGRAPHUS ; 3, 4, 5, 6, HYLURGUS PINIPERDA (natural size and magnified).

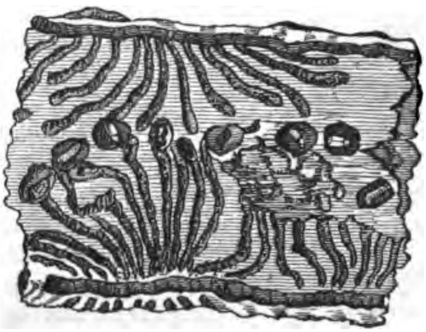


FIG. 35 .—Track of Typographer Beetle.

656. The second family of the Tetramerous Coleoptera has received the name of XYLOPHAGI (or *wood-eaters*), on account of the peculiar habits of the Beetles composing it. They usually live in wood, which their larvæ pierce in every direction; and, when abundant in forests, especially those of pines and firs, they destroy large numbers of trees in a few years. They are destitute of the prolonged muzzle of the last order, and have short antennæ, thickened towards the tips (Fig. 353). One of the most destructive species is the *Bostrichus typographus*, or the Typographer beetle (so named from the figure of its burrows), which has at different times ravaged the forests of Germany. It devours, both in the larva and perfect states, the soft wood beneath the bark, which is most essential to the vegetative processes; and thus causes the death of the tree. It was reckoned that a million and a half of pines

were killed by this species alone in the Hartz Forest, in the year 1783; and that as many as eighty thousand individuals were ordinarily engaged in the destruction of each tree; whence the whole number at work in the forest at once must have been *one hundred and twenty thousand millions.*

657. Passing over the small family PLATYSOMA, which closely resembles the preceding in structure and habits, we come to the family LONGICORNES, distinguished by the great development of the antennæ, which are always at least as long as the body, and often longer. The larvæ mostly reside in the interior of trees, or under the bark; and are destitute of feet, or have them very small. They are furnished with robust mandibles, and do much injury to trees, especially those of large size, by burrowing deeply into them. They are vegetable-feeders in their perfect state also, and do great injury to plants; some attacking the leaves, and others the roots. Many of them produce a slight creaking sound, by the friction of the joint which unites the thorax to the abdomen. Several of them are brilliantly coloured, especially the tropical species; and some are remarkable for exhaling an agreeable musky odour. This is the case with a British species, the *Callichroma moschata*, or Musk-beetle, which is about an inch long, entirely green, or shaded with a blue or golden hue,

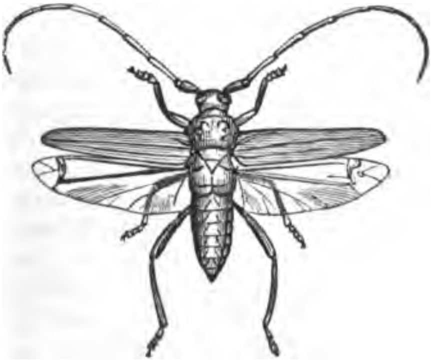


FIG. 355.—CALLICHROMA MOSCHATA.

and very common upon willows. The genus *Acanthocinus* is remarkable for the spiny projections from its antennæ ; and the species represented in the accompanying figure, derives its specific name (which means mirror-bearing) from its having a bright burnished disc on each of the elytra.

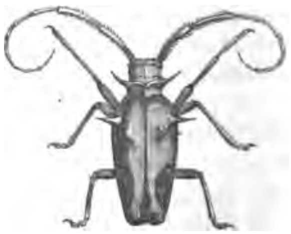


Fig. 356.—Acanthocinus speculifer.

658. The succeeding family Eupoda, is composed of Beetles, which are chiefly remarkable for their habit of feeding upon the stems and leaves of aquatic plants, and upon those of the Liliaceous tribe. One species, the *Crioceris Asparagi*, which is of a blue colour, with the thorax red, and the elytra yellowish-white, with blue markings, feeds in the larva state, on the young sprigs of asparagus ; and is sometimes so abundant, as to do considerable damage to the gardener.

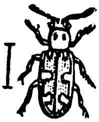


Fig. 357.—Crioceris Asparagi.

659. The sixth family of the Tetramerous section, that of Cyclica, presents many points of interest, on account of the singular forms, and remarkable habits, of many of the species which it includes. The name of the family is derived from the circumstance that, in its typical forms, the body is of a circular or oval shape ; the insects composing it are usually of small size, but are often ornamented with metallic and brilliant colours ; they are generally slow in their motions, timid, and fall to the ground when an attempt is made to seize them, folding their antennæ and legs beneath the body ; many species leap well. The larvæ have six feet, and a soft body ; they feed, like the perfect insect, upon the leaves of different vegetables, where they ordinarily affix themselves by means of a glutinous secretion ; and they frequently undergo their change into the pupa state in the same situation, the cast-skins of the larvæ being crumpled up at the extremity of the body of the pupæ. The first tribe of this family consists of the *Cassidariæ*, or Tortoise Beetles ; these have a flattened body, sur-

rounded by a margin, which is formed by a prolongation from the thorax and elytra, and which even conceals the head; and they are able to lie so close upon the surface of the leaves, that no part of the body or limbs is visible. Their colours are much varied, and often very prettily arranged in spots, points, rays, &c. The commonest species in this country is the *Cassida viridis*, which is no more than 1-16th of an inch long, of a green colour, with black thighs. Its larva, which lives on thistles and artichokes, has a very flat body, with spines set on the edges; and it has the singular habit of covering itself with its own excrement, which it attaches in a mass together, and carries on a sort of fork, arising from its tail. The pupa, also, is very flat, with thin-toothed appendages at the sides of the body; and its thorax is broad, and prolonged forwards in a rounded expansion, which covers the head.

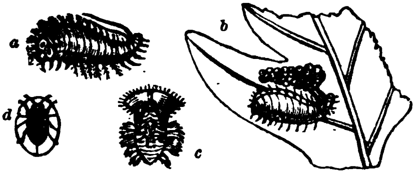


FIG. 358.—CASSIDA VIRIDIS, IN ITS DIFFERENT STATES; *a*, larva; *b*, the same on a leaf, with its covering of excrement; *c*, pupa; *d*, perfect insect.

660. In the sub-family *Chrysomelinæ*, or Golden Beetles, this expansion of the thorax is generally wanting; the body is usually of a hemispheric or ovate form, the base of the thorax being as broad as the front edge of the elytra; and the surface is usually bespangled with the most brilliant hues, in which blue, green, and gold, are pre-eminently conspicuous. Their motions are generally slow, and many of them are destitute of wings. Of the genus *Chrysomela*, the *C. populi* is one of the commonest British species; it is of a blue-black colour, and has red elytra, tipped with black; and it is found upon the willow and poplar, in the larva as well as in the perfect state. As in the preceding group, the exuviæ of the larvæ are found collected into

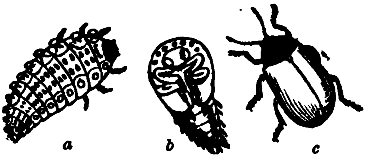


FIG. 359.—CHRYSOMELA POPULI; *a*, Larva; *b*, Pupa; *c*, Imago.

a mass, at the extremity of the body of the pupa; and, in some instances, the larva, before undergoing its transformation, attaches itself to the leaf by a glutinous exudation. Of the apterous group, the *Timarcha* is the principal genus; and the *T. lævigata* is a common British species, varying in length from half to three quarters of an inch, and frequenting woods, turf, and low herbage. It crawls slowly, and emits a reddish-yellow fluid from the joints when disturbed; from which circumstance it is commonly known by the name of the Bloody-nose Beetle. The larvæ bear a strong resemblance to the perfect insect, both in appearance, sluggishness of movement, and general habits; when disturbed, they roll themselves up in the manner of a Wood-louse. The sub-family *Galerucinæ*, may also be mentioned as containing the genus *Haltica;* which is composed of a group of small brightly-coloured Beetles, whose larvæ devour the leaves of cultivated vegetables, and occasionally commit great devastations by their numbers and voracity. One of them occasionally attacks the turnip in this country; and from its great leaping powers, may well be designated the *Turnip-flea.* The Turnip-fly belongs to quite a different group. (§ 686.)

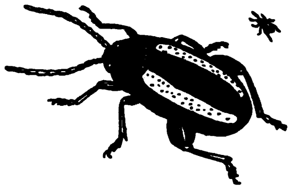


FIG. 360.—HALTICA NEMORUM, or TURNIP-BEETLE; natural size and magnified.

661. Section IV.—TRIMERA. The Beetles of this section are, for the most part, of small size, and not very numerous. Their habits are various, a portion feeding on Fungi, and the remainder chiefly upon *Aphides.* To the latter section belongs the genus *Coccinella,* of which several species are known in this country, under the name of Lady-birds, or Lady-cows. They sometimes appear in great profusion, and have created much alarm. It is erroneous to suppose, however, that they do any injury to vegetation; for, on the contrary, they are of great benefit to plants, by feeding on the Aphides which infest them; and this they do both in the larva and perfect states.

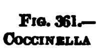


FIG. 361.—COCCINELLA 7-PUNCTATA.

ORDER II.—ORTHOPTERA.

662. In many respects the Insects of this Order resemble the Coleoptera; and they are closely connected with that group by the family FORFICULIDÆ, or *Earwig* tribe, which partake of the characters of both. But they differ from the Beetles, in the softer covering of their bodies; in the partially membranous character of the anterior pair of wings, which seem intermediate between the horny elytra of Beetles and the membranous wings of other insects, and which do not meet when closed along the central line of the back; and in the fan-like manner in which the posterior wings are folded up beneath them, which is permitted by the straight direction of their veins. They differ also in their metamorphosis; for, whilst that of the Beetles is complete, that of the Orthoptera, is only partially so,—the larva and pupa closely resembling the perfect insect in form, walking and feeding in the same manner, and differing in little else, than the absence of the wings and wing-covers, which are gradually and visibly developed in the pupa.—This Order comprises numerous well-known insects, often of large size and splendid colours, such as Grasshoppers, Locusts, and Walking-Leaves;—as well as Cockroaches and Earwigs. Some of the largest of known insects belong to it; a few species attaining a length of eight or nine inches, and an equal expansion of wings. Comparatively few of this Order are inhabitants of temperate regions; and it attains its greatest development, both as to the number of species and individuals, their size, and their colour, between

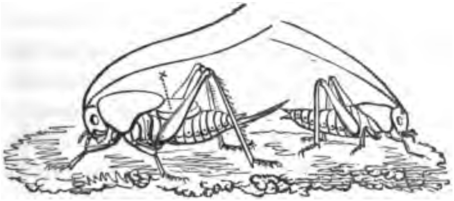


FIG. 362.—LARVA AND PUPA OF GREAT GREEN GRASSHOPPER.

the tropics. All the known Orthoptera are terrestrial, both in their perfect and two previous states. Some are purely carnivorous, and others are adapted to a mixed diet,—the Cockroaches, for example, being capable of feeding on almost any kind of organised matter; but the greater number feed upon plants. Hence from their large size, and the enormous quantity which each individual can devour, they are among the most destructive of all the Insect tribes, when they appear in large numbers. This is particularly the case with the Locusts in warm countries; the ravages of which not unfrequently cause famine and pestilence, both among men and beasts. Some details upon this subject will be given in the latter part of this volume.

663. Before treating of the true Orthoptera, we shall first notice the family Forficulidæ; which has been raised by some into a distinct order, under the name Dermaptera, or leathery-winged (§ 637). The *Earwigs* and their allies, of which this group is composed, have the anterior wings formed into elytra, possessing a consistence intermediate between that of the horny elytra of Beetles, and the parchment-like anterior wings of the Orthoptera; they are of small size; and they meet, when folded together, upon the central line, as in Beetles. The posterior wings are folded across when at rest, as in the preceding Order, but the part thus doubled down is itself folded in a fan-like mode, as in the Orthoptera. These insects are further distinguished by the two large appendages at the posterior part of the body, which form a pair of forceps (Fig. 306). They are very common in damp situations, where they assemble in troops under stones and the bark of trees; they do much injury to the flowers and fruits of our gardens, and they will devour the bodies of their dead companions. Their forceps appears to serve as an instrument of defence; whether it answers any other purpose is not known. Their common name is derived from the incorrect notion, that they have a peculiar tendency to creep into the ears of sleeping persons.

664. The proper Orthoptera may be divided into two principal sections; in the first of which the legs are nearly of the

same length and adapted for walking or running, whence they are named CURSORIA; whilst in the second, the SALTATORIA, the thighs of the hind-legs are of disproportionate length, and are adapted for leaping. These two groups also differ in the arrangement of the wing-covers and wings, when closed; for they usually rest horizontally in the body (and consequently more in the manner of those of the Beetles) in the first; whilst in the second they meet at an angle, like the two sides of a roof. The second section is further distinguished by the creaking sound, which the males have usually the power of emitting, by the friction of their legs against the body.

665. The first section may be divided into three families, which differ considerably from each other in general form,—the BLATTIDÆ, or *Cockroaches;* the MANTIDÆ, or *Mantis* tribe; and the PHASMIDÆ, or *Spectre* insects. In the first of these, the legs are adapted for running; in the second, the fore-legs are converted into claws for seizing the prey; and in the third, the limbs are adapted only for walking or creeping.—The BLATTIDÆ are in many respects intermediate between the Forficulidæ and the more typical Orthoptera; in fact, their general resemblance to the Coleoptera occasions them to be commonly regarded as Beetles. These well-known insects are now pretty generally

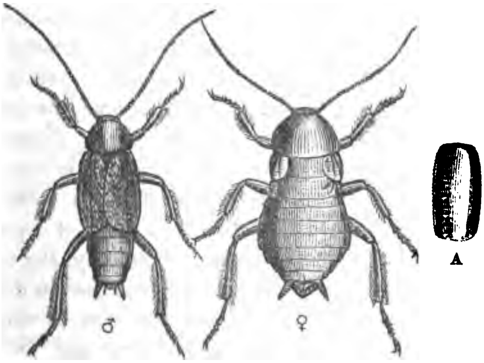


FIG. 363.—BLATTA ORIENTALIS, MALE AND FEMALE.

diffused over temperate climates; although most of the species are believed to have been originally natives of tropical regions, where only they attain their full development. They are nocturnal in their habits, and active in their movements along the ground; their powers of flight are usually inconsiderable, the wings being usually small in proportion to the size of their bodies; and they are extremely voracious, devouring with avidity almost every kind of organised matter. In cold climates the wings are scarcely enough developed, even in the male, to raise the body from the ground; whilst in the female they are almost entirely absent. The species which is commonest in this country, the *Blatta orientalis*, is so named from its being supposed to have been originally a native of the East Indies; it has, however, been so long domesticated with us, that its time and mode of introduction are uncertain. In common with most other species of Blatta, it ejects a dark-coloured fluid from the mouth, emitting a very disagreeable odour, of which it is difficult to get rid, and attaching itself to whatever the insect has crept over. The tropical species are larger and more voracious; one of them, which attains the breadth of six inches when its wings are expanded, is known in the West Indies by the name of *drummer*, from the sharp knocking sound which it produces, and which is sometimes kept up through a whole night by several individuals replying to each other; and it is said to attack sleeping persons, and even to devour the extremities of the dead.—Notwithstanding the disgusting character which attaches to these insects, on account of their appearance and habits, they present several points of much interest to the Naturalist, especially in regard to their mode of depositing their eggs. Instead of being discharged separately, the eggs are collected together and deposited at once, enclosed in a large horny case or capsule (equalling half the abdomen of the female in size), and generally of a more or less oval and flattened form, like a small bean with one edge more flattened than the other (Fig. 363, A). Along this edge there is a slit, from end to end of the capsule; and the plates which form the edges of this slit are jagged or toothed, fitting closely to each other. The interior of this capsule is divided into two spaces, in each of which is a row of separate chambers, every one of them enclosing an egg. The capsules are attached by means of a glutinous secretion, in such situations as the females select as most fit for their reception; and the slit part is strongly coated with cement, so as to be even stronger than the other parts. In this capsule, the young larvæ are hatched; and they immediately discharge a fluid, which softens the cement, and enables them to push open the slit; through this they escape, and the slit then shuts again so closely, that it appears as entire as before.

666. The MANTIDÆ are purely carnivorous insects, of which none are natives of this country. They differ much from the Blattidæ in the form of the body; which, instead of being flattened and oval, is narrow or compressed, and lengthened. The first pair of legs is enormously elongated, and forms a very powerful organ of attack. These insects frequent trees and plants; and the forms and colours of their wings and bodies are often so adapted to those of the leaves and twigs which surround them, as to give them remarkable power of eluding observation. Most of the species asume, when lying in wait for their prey, an attitude which has been mistaken by the inhabitants of the countries where they are found, for that of prayer; and the

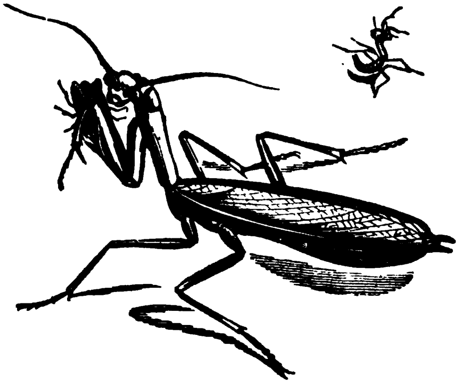


FIG. 364.—MANTIS, IN THE ACT OF SEIZING A FLY, WITH A YOUNG ONE JUST HATCHED.

names commonly given to the Insects are such as to express this. Thus the best-known species, which is very common in the south of France and Italy (Fig. 364), has received the name of Mantis *religiosa*, the Praying Mantis, or Soothsayer; and is termed by the French *prie-Dieu*. This is regarded by the Turks as an object of superstitious veneration; and many absurd stories are on record, in regard to its habits. The peculiar attitude in question, however, is nothing else than the position in which the prey is most readily seized;—the front of the thorax being elevated, and the two fore-legs being held up together like a pair of arms, prepared to seize any animal that may fall within their reach. These insects are extremely voracious; and, if kept together without food, they will fight until one is killed, the victor then devouring his conquered adversary.—The eggs are included in a capsule, as in the Blattidæ.

667. The third family of the Cursoria, that of PHASMIDÆ, or *Spectre Insects*, is also restricted to warm climates; and consists of a small number of extremely curious species, commonly known under the names of *Walking-Sticks*, *Walking-Leaves*, &c., from their resemblance to those objects. Their whole structure indicates a sluggish mode of life; they subsist solely upon vegetables, and crawl slowly among the branches of low shrubs, devouring the young shoots. In fact, their mode of life bears a strong analogy to that of the Sloths among Mammalia. Their means of escape from enemies consist entirely in their very close resemblance to the objects in the midst of which they live. Some of them are destitute of wings, and have the appearance of dead twigs; the legs being generally extended in a straight line so as

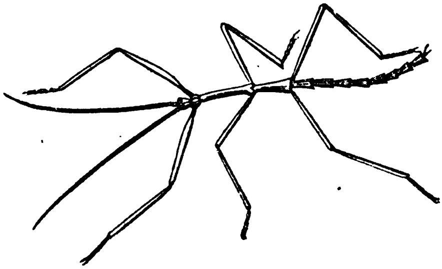


FIG. 365.—PHASMA (BACTERIA) FRAGILIS, OR WALKING-STICK.

to look like the lateral twigs; whilst the absence of motion in the Insect for a long period adds strength to the deception. Others, which possess wings, have still the same general appearance; these organs being laid flat along the back, so as not to extend beyond the body. In others, again, the wings have the form and aspect of withered leaves (Fig. 366); whilst the wing-covers are very short. And lastly, there are a few, in which the wing-covers are of a brighter hue, and of larger size, covering in the wings, and giving to the whole animal the appearance of a fresher leaf. These curious insects are for the most part natives of the East Indies, the East Indian Archipelago, Australia, and South America. Their larvæ differ but little from the perfect insects, except in their colours and in the absence of wings; and there are several species, as we have seen, in which these are never developed. It not unfrequently happens that they lose a limb by violence; and this is reproduced, provided the complete growth of the animal has not been attained. The eggs are laid separately, in the usual manner.

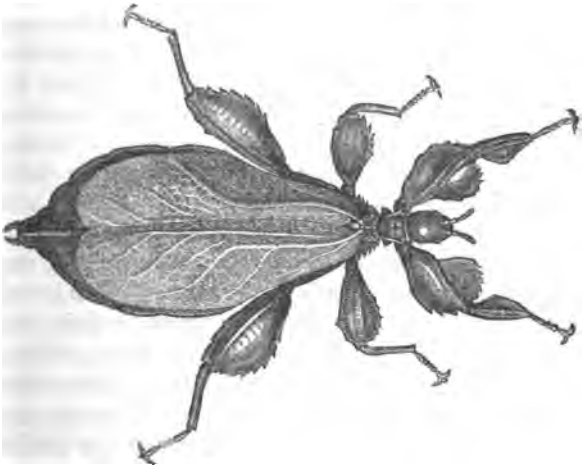


FIG. 366.—PHYLLIUM SICCIFOLIUM.

668. The section SALTATORIA consists of numerous species

allied to the well-known Crickets, Grasshoppers, Locusts, &c.; all of them being adapted, by the peculiar conformation of their hind-legs, to move by leaping rather than by running. Besides this peculiarity, they all agree in depositing their eggs in the ground: and they generally effect this by means of a horny tubular prolongation of the last segment of the body, or *ovipositor*, such as we shall meet with in the order Hymenoptera. There are three distinct groups in this section;—namely, the ACHETIDÆ or *Crickets;* the GRYLLIDÆ or *Grasshoppers;* and the LOCUSTIDÆ or *Locusts;* but the differences between them are scarcely such, as to entitle them to rank as distinct families. The *Crickets* are essentially inhabitants of the ground, in which many of them burrow, both in the larva and perfect states; few of them have any powers of active flight. One of the most important species of this family is the *Gryllotalpa vulgaris,* or *Mole-Cricket* (Fig. 300), which derives its name from the peculiar similarity in its anterior extremities, and from the resemblance in its habits, to those of the Mole. It is about an inch and a half long, and of a brown colour. In making its burrows, it cuts through or detaches all the roots of plants which it encounters; but it does not do this so much for the purpose of feeding upon them, as to make a passage in search of insects and worms. The female forms, in June and July, at the depth of about six inches from the surface, a rounded cell, smooth within, and resembling with its gallery a bottle with a long bent neck; in this she deposits from 200 to 400 eggs; and the young remain in society for some time after they are hatched. The larvæ are at first white; but in other respects they resemble their parents, except in their smaller size and their want of wings; after their first moulting, they disperse, and soon gain their darker colours; and they are about three years before they arrive at the perfect state. Their wings are so little developed, that the possibility of the flight of the insects has been denied. It is remarkable that the various species of this singular genus should be spread over the whole globe. The *House-Cricket* (Fig. 367) is too well known to require particular description; it takes up its abode in the neighbourhood of the fire-places of rooms on the groundfloor, sometimes even burrowing into the mortar, even within a few inches of the fiercest fires; and here it remains during the winter months, becoming torpid in its haunts, if the fire be discontinued. In the summer, however, it frequently goes forth to the gardens, and seeks a habitation in the crevices of garden-walls, &c., as if it then found heat enough out of doors. The *Field-Cricket* is much larger, and also rarer, than the preceding; it frequents hot sandy districts, in which it forms its burrow at the side of footpaths, &c., in situations exposed to the sun, to the depth of from six to twelve inches; and sits at its mouth watching for its prey, which is said to consist of other insects. This is one of the most noisy of all the Crickets.

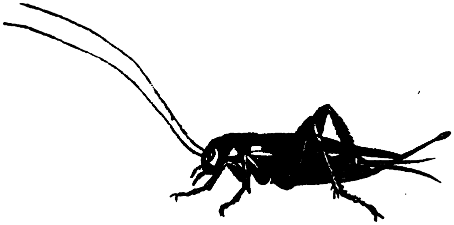


FIG. 367.—HOUSE-CRICKET.

669. The *Gryllidæ*, or *Grasshoppers*, are distinguished from the preceding by the roof-like position of the wing-covers, which in the crickets fold horizontally; but agree with them in having long thread-like antennæ, and a talc-like spot at the base of the wing-covers in the males. They are distinguished, on the other hand, from the Locusts with which they agree in the first of these characters, by the inferior robustness of the body, and the length and slenderness of the legs and antennæ. The *Gryllus viridissimus*, or Great Green Grasshopper, represented in Fig. 368, is the largest British species of this Order, and one of the largest of our native insects; its length being about two inches, and its breadth when the wings are expanded being three inches and a half. Many species of this genus are destitute of

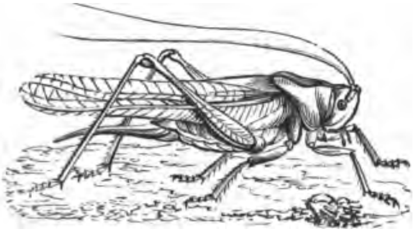


FIG. 368.—GRYLLUS VIRIDISSIMUS.

wings, or have only small wing-covers. Of their voracity a curious instance is mentioned by Mr. Westwood; who states that on one occasion he placed a specimen of the large green species in a box, together with one of its legs which it had accidentally jerked off; and on opening the box the next morning, half the leg was devoured. Amongst the foreign species of this group, there are some which bear a most singular resemblance to the fresh leaves of various plants.

670. The last group of this Order consists of the various tribes of migratory *Locusts*, together with several which are ordinarily ranked as Grasshoppers, but which agree with the Locusts in the shortness of their antennæ, and the robustness of their bodies and limbs (Fig. 369). These leap with much greater energy than the preceding, and have a much longer-sustained flight. The powers of devastation possessed by the Locusts are almost inconceivable; for they are produced in vast numbers, and live in societies, so as speedily to destroy the vegetation of the spot on which they have settled. Thence they take their flight in vast multitudes to adjoining districts; and so great is the number of which these swarms consist, that it is not speaking figuratively to say that the sky is darkened by their passage. Their ravages usually continue until they are checked for want of a further supply of food; for as the instinct of the Locusts leads them to continue their flight in the same direction, they are at last stopped either by the desert or the sea; and sometimes a storm, carrying them out of their course, or hurrying them on in it,

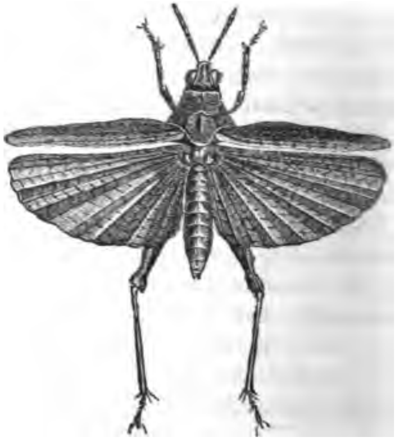


FIG. 369.—PNEUMORA.

effects a clearance much more speedily than any other cause could do. Of the cause of the occasional appearance of the Locusts, in such vast multitudes, no satisfactory explanation has been given. Of these Insects there are several different species, which are distributed over the tropical and the warmer temperate regions of the globe; and in many parts they are used as food by the inhabitants of the countries they infest.

ORDER III.—NEUROPTERA.

671. The Neuroptera correspond with the two preceding Orders, in having a mouth adapted for mastication, but differ from them as to the conformation of the wings; the anterior as well as the posterior pairs being here membranous and transparent. In both pairs of wings, the veins form a very beautiful and minute network, subdividing and uniting again, so as to divide the whole surface into a large number of minute cells, which much exceed in number those of the wings of any other tribe of insects (Fig. 370). Although the posterior wings are usually as large as the anterior, or sometimes even larger, they are occasionally much smaller, and may even be altogether wanting.

675. The body of the Insects of this Order, which contains the well-known *Dragon-flies*, *May-flies*, *Ant-lions*, *White Ants* or *Termites*, and others, is generally prolonged, and destitute of any very hard integument. These insects are of intermediate size; none of them exceeding in dimensions the largest Dragon-flies of this country; whilst none exhibit the minuteness of some Hymenoptera and Coleoptera. They differ in the character of their metamorphosis, as well as in their adult structure; for in some the metamorphosis is complete, the larva undergoing a marked change of form; and in others there is not much difference, except in the absence of wings, between the larva and perfect insect. By these differences the Order may be divided into two sections; in the first of which the insect is active during the whole of its pupa state; whilst in the second, it is quiescent, except just before its last metamorphosis. The first of these

groups may again be subdivided into three families;—the LIBELLULIDÆ or *Dragon-flies*;—the EPHEMERIDÆ, or *May-flies*; and the TERMITIDÆ or *White Ants*. In the first two of these, the larvæ and pupæ are inhabitants of the water, and respire by means of peculiar organs placed along the sides or at the extremity of the abdomen; whilst in other respects, they nearly resemble the perfect insect. They creep out of the water to undergo the final metamorphosis.

673. Section I. The LIBELLULIDÆ, or *Dragon-flies*, are well-known insects; being easily distinguished by the slender form of their bodies, their varied colours, their large gauze-like wings, and the rapidity of flight with which they pursue other insects on which they prey. They have a large head, of rounded form, furnished at its sides with two very large compound eyes, and with three ocelli, situated upon its upper surface. Most of this tribe frequent the neighbourhood of water; and may be frequently seen skimming over the surface of ponds or streams, in search of flies, gnats, and other small insects. An American species has been recently described by Mr. Newport, which seems to be actually provided with *branchial* or gill-like appendages, even in its perfect state; and the habits of this insect appear to be pecu-

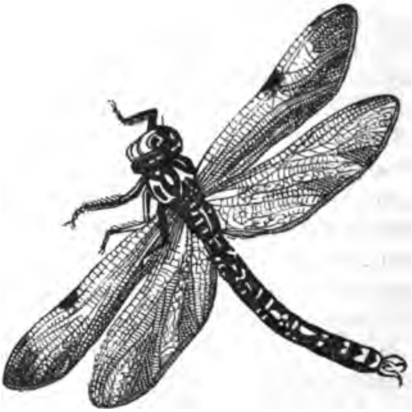


FIG. 370.—LIBELLULA CANCELLATA.

liarly aquatic. The eggs are deposited upon aquatic plants, and the larvæ are thus produced in the element in which they are at first to reside. The head of the pupa is remarkable for the singular form of the portion which takes the place of the lower lip; this is a kind of mask, composed of several pieces, and covering the mandibles, maxillæ, and nearly all the under side of the head, when it is closed together; but being capable of extension and unfolding, and being furnished with a pair of sharp claws at its upper part, so as to become the instrument by which the animal seizes its prey. The posterior end of the abdomen, in the early state of the Dragon-flies, is usually the seat of the respiratory function. This is commonly performed by means of three leaf-like membranous organs, which are situated inside the extremity of the intestine, or sometimes within a sort of prolonged pyramidal tail; in using these, the animal draws a supply of water into the rectum; and then forces it out violently, by which act it also impels itself through the water. The succession of jerks thus produced, is the chief means of locomotion of the larvæ of the Dragon-flies, and serves to distinguish them from all other aquatic larvæ; so that they are very easily recognised. Several

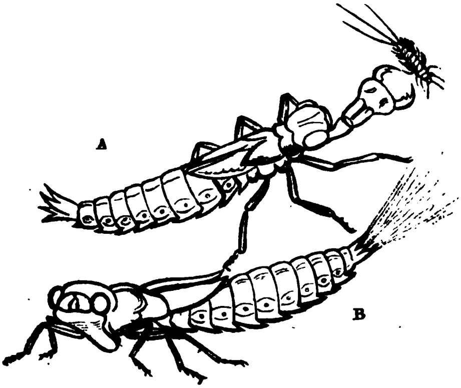


FIG. 371.—A, the pupa with its mask. B, the same with the mask closed, and discharging a current of water.

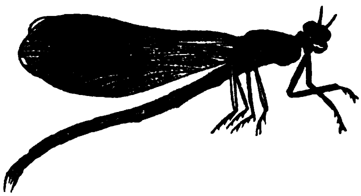


FIG. 372.—AGRION VIRGO.

species of Dragon-flies exist in this country; the largest, which is probably not surpassed in size by any others, measures two inches and a half in length; but the foreign species are usually more brilliantly coloured.—In the *Agrions*, the wings stand perpendicularly when in repose, instead of horizontally as in the Dragon-flies; and the mouth is somewhat differently constructed. The species represented in the accompanying figure is of a golden-green, or bluish-green colour, with the wings blue; and in common with many other less conspicuous species, it is an inhabitant of Britain.

674. The EPHEMERIDÆ, or *Day-flies*, receive their name from the short duration of their lives in the perfect state. The history of their early condition has been already given (§ 632).

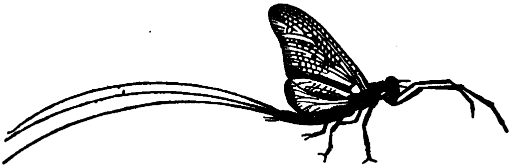


FIG. 373.—EPHEMERA.

Their last change takes place near sunset on the fine days of summer and autumn; and they are sometimes produced in such vast numbers at one time, that the ground is covered with them after their death, and their bodies are carted away as manure. They take no food after their final change; and as the propagation of the race is then their only object, they die almost as soon as it has been performed, often in a few hours after they have quitted the water,—the duration of their lives in their previous conditions having been two or even three years.

675. The TERMITIDÆ, or *White Ants*, are terrestrial, active, and carnivorous or omnivorous, during all their stages. In

several points of their structure, they resemble the Orthoptera; whilst in their habit of living in societies, they resemble a large proportion of the Hymenoptera. There is, however, as we shall hereafter see, a considerable difference in the duties of the several tribes of which these communities consist. A more particular account of their operations will be given in a later part of this volume; and at present it will be sufficient to say, that the larvæ resemble the perfect insect, except in the absence of wings, and are the *workers.* Among the adult insects there are some, which never acquire wings, and in which the reproductive organs are not developed; these, which are termed the *soldiers* (Fig. 374), have the head much larger and longer than that of the larvæ, and the mandibles are very long and cross each other; they are far less numerous than the larvæ, and live near the outer surface of the nest, so that they are the first to make their appearance when it is attacked; and they are also stated to compel the workers to labour. The winged males (Fig. 375) and females, when they have arrived at their perfect state, quit their habitation, and fly abroad during the evening or the night, in great

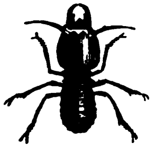


Fig. 374.—Soldier Termes.

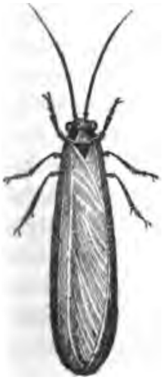


Fig. 375.—Termes in perfect state.

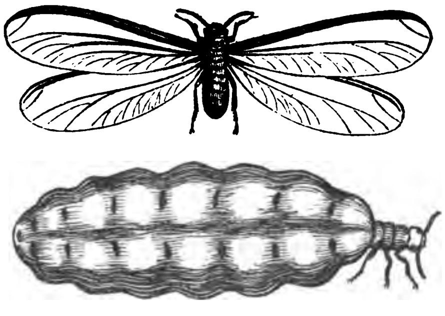


Fig. 376.—Queen in the winged state, and filled with Eggs.

numbers; they lose their wings before the morning, however; and the greater part of them, falling to the ground, become the prey of birds, reptiles, &c. The females, however, are sought by the workers, who imprison them in royal chambers, as they have been termed, in the centre of the nest. The abdomen subsequently attains an enormous size, from the quantity of eggs it contains; and these, when laid, are carefully tended by the workers, and defended by the soldiers.—Some small species belonging to this family, but not at all resembling the true Termites in habits, are found in our country; one of them, which is found in collections of dried plants, is remarkable for producing a slight ticking noise; it is represented of its natural size, and magnified, in the accompanying figure.

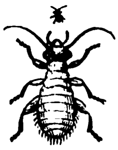


FIG. 377.—PSOCUS PULSATORIUS.

676. Section II. Of the division of Neuroptera in which a more complete metamorphosis occurs, the pupa passing into an inactive condition, the family of MYRMELEONIDÆ, or *Ant-lions*, is one of the most remarkable. As its peculiar habits in the larva state have already been elsewhere described (ANIM. PHYSIOL. § 697), they need not be here dwelt on. When the larva has attained its full growth, and is ready to assume the pupa state, it spins a perfectly round cocoon of a silky matter, the exterior of which it covers with sand; and from this the perfect insect makes its escape at the end of fifteen or twenty days. None of this group are found in Britain.

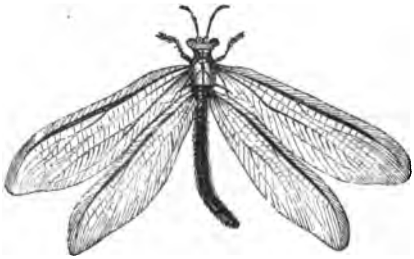


FIG. 378.—MYRMELEO.

677. The family HEMEROBIIDÆ, which is closely allied to the preceding, is remarkable for the exceeding brilliancy of the eyes in most of the species, and for the delicate structure and varied colours of the wings. The eyes often resemble the most

highly-polished gold; and the wings frequently reflect the prismatic colours; so that, although of small size, these insects are very conspicuous. They are for the most part inhabitants of temperate climates; and many species abound in Britain. They usually fly during the twilight, remaining inactive during the day; and they emit a very disagreeable odour when handled. The females deposit their eggs upon plants, attaching them at the extremity of a long slender footstalk, the base of which is fastened to the leaf; this footstalk is composed of a white viscid matter, discharged by the female at the time of laying her egg, and speedily hardening by exposure to the air. The eggs, thus curiously fixed in small clusters, have the appearance of minute fungi. The larvæ are extremely voracious, and especially attack the Aphides; unlike the Ant-lions, however, these Aphis-lions (as they have been termed) do not remain concealed in one spot, but wander in search of their prey where it is to be found in the greatest abundance. So ravenous are they, that they do not require more than half a minute to suck the juices from one of the largest Aphides; and they not unfrequently attack each other, the conqueror in like manner sucking the body of the vanquished. During the summer they arrive at their full growth in about fifteen days; they then spin a silken cocoon, in which they enter as inactive pupæ during the winter; and come forth in the succeeding summer.

678. The remaining families of this Order may be very briefly noticed. The Sialidæ are a small group of moderate or large-sized Neuroptera, having very large anterior wings. They are nevertheless slow and inactive in their habits, and frequent the neighbourhood of water, in which they pass their larva state. The ordinary species *Sialis lutaria*, or *May-fly*, is a well-known bait with the angler, being produced during the spring months in large quantities; it is of a dull brown colour, and may be found on the walls or palings near the water. The larva is furnished with appendages for aquatic respiration, strongly resembling those of the Ephemera; but when arrived at its full growth, it quits the water and burrows into the adjoining bank, in which it excavates a sort of cell. Here it

is transformed into a pupa, which remains inactive, with its limbs laid along the breast, but which is lively when disturbed; and here, too, it undergoes its final change.

679. The PANORPIDÆ are known under the name of *Scorpion-flies*, on account of the remarkable conformation of the posterior extremity of the abdomen in the male. The sixth and seventh segments are very slender and somewhat curved upwards, so as to constitute a sort of tail; whilst the eighth is greatly thickened, forming an oval mass, armed with a pair of forceps, and capable of free motion in any direction. The species represented in Fig. 379 is a very common British insect, frequenting hedges and woods. The Scorpion-flies are very active, and prey upon other insects in the perfect state. The abdomen of the female is also prolonged into an *ovipositor;* by which she can deposit her eggs in deep holes or crevices.

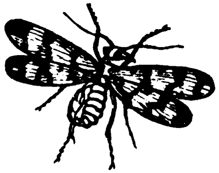


FIG. 379.—PANORPA COMMUNIS.

680. The RAPHIDIIDÆ are commonly known as *Snake-flies*, from the elongated form of the head and neck, and the facility with which they move the front of the body in different directions. They are of comparatively small size, agile in their movements, and possessing powerful jaws; they are chiefly found in the neighbourhood of woods and streams; and they prey upon other insects inhabiting the same situations. Finally, the MANTISPIDÆ seem to connect this order with the preceding; having the mouth formed upon the plan of that of the Neuroptera; but having the fore-legs converted into prehensile claws, and the first segment of the thorax lengthened so as to elevate them, almost exactly as in the Mantis.

681. We shall next mention the small intermediate group of PHRYGANEIDÆ, or *Caddice-flies*, which are by some Entomologists regarded as constituting an aberrant family of the Neuroptera, whilst others raise them into the rank of a distinct Order, TRICHOPTERA,—a name derived from the hairy covering

with which their wings, as well as their bodies, are beset. In this character, as also in the arrangement of the nerves of the wings, they bear a strong resemblance to the Lepidoptera.

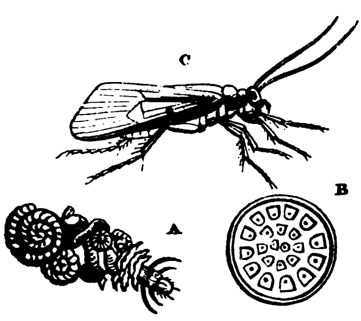


FIG. 380.—PHRYGANEA GRANDIS.—A, Larva in its case; B, grating; C, Imago.

682. These Insects are chiefly remarkable on account of the habits of the larvæ, which are well known under the name of *Caddice-worms*. These reside in cylindrical cases, open at each end, to which they attach various matters, as bits of stick, weeds, pebbles, or even small living shells, by the assistance of silken threads, which they spin from the mouth. These cases they bear about with them; protruding the three first segments, with their legs, when they creep forwards; and withdrawing these upon the slightest alarm. They are never known to quit these cases of their own accord. Different species appear to prefer different materials for the construction of their cases; but they have the power of employing almost any which fall in their way, when there is a deficiency of those usually preferred. The food of some of the larvæ is vegetable; but others prey upon small aquatic larvæ, such as those of the Neuroptera.—When about to assume the pupa state, the larvæ fix their cases to some solid substances beneath the water, and close the two extremities with a kind of grating, that admits of the passage of water through the tube, which is necessary for respiration. A short time before they are to assume their perfect form, they make their way out, by means of the pair of hooked jaws, with which they are then furnished, and swim about with great activity by means of the two hind legs, crawling occasionally upon the four first. In order to throw off their pupa-case, the larger species crawl up plants out of the water; but the smaller ones merely come to the surface, and there undergo their transformation,—using their old envelope as a boat, out of which they rise to

expand their wings, much in the same manner as Gnats. The perfect Caddice-flies run with great agility, but their flight is awkward,—except in some of the smaller species, which assemble in troops and fly over the surface of the water towards sunset. They are nocturnal in their habits, and not unfrequently enter our houses, being attracted by the light. They emit a disagreeable smell when touched. These insects are very numerous in Britain; no fewer than 190 species having been described.

ORDER IV.—HYMENOPTERA.

683. In the membranous character of their four wings, the insects of this Order resemble the Neuroptera; but they cannot well be mistaken for them. The anterior wings are usually much larger than the posterior; and the veins or nerves* are much fewer in number than in the Neuroptera, and do not form a close network by their ramifications, as in that Order. In some of the minute species, the wings are almost, or even entirely, destitute of nerves. Another character furnished by the wings consists in the connection of the anterior and posterior wings on each side, during flight, by means of a series of minute hooks along the front edge of the latter, which catch the hinder margin of the other, so as to produce one continued surface on each side.—The principal character of the Order, however, is derived from the structure of the mouth; for, although considered as *mandibulate* insects, the Hymenoptera are much better fitted for imbibing their nourishment by suction, than for obtaining it by mastication (§ 614). The Hymenoptera are also peculiarly distinguished by a prolongation of the last segment of the body in the females, into an organ,—which is, in one division of the Order, a *sting*,—and in the other, an *ovipositor*, or instrument for the deposition of the eggs, usually possessing the power of boring a hollow for their reception.

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* These terms are used to mean the same things; namely, the hard framework on which the membrane of the wing is extended. They must not be understood as indicating any analogy to the veins and nerves of higher animals.

684. The Hymenoptera are further remarkable for the great development of their *instinctive* faculties, and of their *locomotive* powers. It is in this order that we find the most remarkable examples of contrivance, and of skilful adaptation of means to ends; but this adaptation results, it would appear, not from an exercise of *intelligence* on the part of the animals themselves (as in Man and the higher Vertebrata), but from their blindly following out a path laid down for them by the Almighty Designer (ANIM. PHYSIOL. § 475). That the two classes of faculties just mentioned should attain their highest development in the same group (the Neuroptera may, perhaps, be included in this statement), is a very remarkable and interesting fact. Considering these powers as those which are peculiarly characteristic of the *animal kingdom*, we may regard these groups of Insects as the types or centres (§ 35) of that kingdom. As we descend the scale, we find these powers gradually disappearing, whilst the organs of vegetative life (which, as we have seen, are of comparatively small size in Insects) gain the predominance, so that in the Zoophytes we have an evident approach to the Vegetable kingdom. On the other hand, as we ascend the Vertebrated series, we find the Instincts gradually superseded by Intelligence, which in Man becomes the sole director (at least in the well-governed mind) of the actions, keeping the instincts in subordination; and through his immortal soul we are connected with that kingdom of *pure Intelligence*, in which we have reason to believe that *Mind* exists unfettered by the imperfections of its corporeal instruments, and of which we are encouraged to hope that we shall ourselves be sharers, when "this corruptible shall have put on incorruption."—The mutual adjustment of the various instinctive actions of a large number of individuals, so that they all work together towards a common end, like the parts of a machine, is nowhere so remarkable as in the *social* Insects, which are principally restricted to this order; and the Bees, Wasps, Ants, Ichneumons, Saw-flies, Gall-flies, and many other groups contained in it, have consequently attracted the attention of the observer of nature from a very early period.

685. The Insects of this Order undergo a complete meta-

morphosis; the larvæ being more imperfect than those of almost any other tribe; and the pupæ being quite inactive. In the greater proportion of the order they are destitute of feet, and resemble little worms. Their support is provided for, either by the deposition of the eggs in situations where the future grub will be furnished with an ample supply of food—the parent being directed to these by an unerring instinct,—or by the active exertions of the parents, which convey to the young the food which they have themselves collected; or by similar exertions on the part of a race destitute of peculiar sex (hence termed *neuters*), on whom this charge more especially devolves. When arrived at their full growth, and after undergoing several previous changes of skin, the larvæ are transformed into inactive pupæ; in which all the limbs of the future insect are visible, encased in distinct sheaths, and folded on the under surface of the thorax. During this part of their existence they take no food. In their perfect state, these insects, for the most part, take but little nourishment; and this consists almost exclusively of the nectar of flowers. Many of them, however,—such as the Wasps,—attack and destroy other insects; but these are often destined, not for their own support, but for the nourishment of the young.—This Order is of considerable extent, being inferior only to the Coleoptera; and it has been estimated to contain one-fourth part of the whole Insect population. It attains its greatest development in warm climates; for, of the numerous species inhabiting this country, the greater part are of very small size, and some are almost of even microscopic minuteness. None of the species attain any great dimensions; very few of them exceeding, or even attaining, two inches in length, or three in

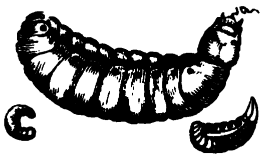

Fig. 381.—Larvæ of Bee, natural size, and magnified.

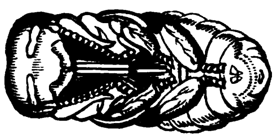

Fig. 382.—Pupa of Bee.

the expansion of their wings. The duration of their lives, from the hatching of the egg to the final change, is believed never to exceed a year.

686. This Order may be primarily divided into two groups, according to the nature of the organ in which the body of the female terminates;—the end of the abdomen being prolonged, in the Terebrantia, into a saw or borer for the deposition of the eggs;—whilst, in the Aculeata, it is formed into a sting or piercer connected with a poison-reservoir. In the former group, the number of joints in the antennæ is extremely variable; whilst in the latter, it is always twelve in the female, and thirteen in the male. The Terebrantia may be again divided into the Phytiphaga, of which the larvæ feed upon vegetable matter; and the Entomophaga, in which they generally feed parasitically upon living insects. The Aculeata are in like manner divided into the Prædones, or predaceous tribes, which do not collect pollen, and in which the larvæ feed upon other insects stored up for them, or upon fluids stored up by the neuters; and the Mellifera, in which the larvæ feed upon honey or pollen-paste, collected and stored up for them. All these have characteristic distinctions in their adult form; on which it would not be accordant with the character of this work to dwell minutely. The division of the Order into sections may be better understood from the following tabular arrangement of them:—

Possessing ovipositor—Terebrantia	*Larvæ vegetable-feeders*	I. Phytiphaga.
	Larvæ parasitic	II. Entomophaga.
Armed with sting—Aculeata	*Predaceous in habits.*	III. Prædones.
	Honey-collectors	IV. Mellifera.

687. Section I. Terebrantia Phytiphaga. The principal family of this section is that of Tenthredinidæ, or *Saw-flies*, so named from the saw-like character and action of the ovipositor. With this instrument they make a succession of small holes in the branches or other parts of trees, into each of which they insert an egg, closing the hole with a drop of frothy fluid. The tissue in the neighbourhood of the wound swells up from its irritation; and sometimes becomes a kind of *gall*, either woody or pulpy, accord-

ing to the parts injured, which forms the abode of the larva in some cases, during its whole life as such, and up to its final metamorphosis; but in general the larvæ come forth at an earlier period, and feed upon the exterior of the leaves. They greatly resemble the Caterpillars of Lepidopterous insects; but usually differ from them as to the number of their feet, which are either restricted to six, answering to those of the perfect insect, or amount to eighteen or twenty-two. In order to undergo their change into the pupa state, they spin a cocoon, either on the earth or on the plants on which they have fed; but they do not become pupæ, until they have been inclosed in this for many months, and only a few days before they come forth as perfect Saw-flies. To this group belongs the *Athalia centifoliæ*, or *Turnip-fly*, which occasionally appears in this country in such vast numbers as to produce the greatest devastation. The larva is twenty-two-footed, and of a greenish-black colour; whence it is commonly known by the appellation of the *nigger*, or *black caterpillar* of the Turnip,—to which plant it is chiefly detrimental, by devouring the leaves, and thus totally destroying the crop in an incredibly short space of time. It was especially abundant in the south-eastern counties of England, in the years 1835, 1836, and 1837. The appearance of the black larvæ is preceded by that of the imago, a pretty yellow and black insect, which is first seen hovering over the turnip-fields about the middle of May or the beginning of June; it deposits its eggs in the soft tissue of the leaf, puncturing the cuticle by its ovipositor; and these are hatched in five or six days. In a few days

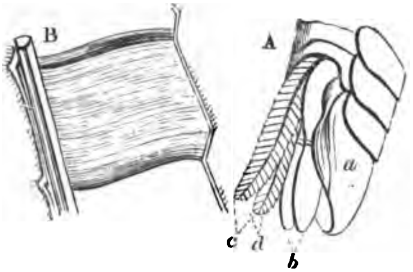

FIG. 383.—A, extremity of the abdomen of the Sawfly, showing the two saws, *c*, and their supporters, *d*, extended; *a*, the terminal joint of the abdomen; and *b*, the two internal horny sheaths. B, a small portion of one of the saws very highly magnified.

more, a whole field has been often devastated by the voracity of the larvæ, which devour the soft tissue of the leaves, leaving only their skeletons and stalks. The most effectual remedy for these attacks was found to be the introduction of Ducks into the fields, by which the plants were cleared of the larvæ more effectually than they could be by any other means. Many other species exist, however, almost equally injurious to different tribes of plants. Thus the Gooseberry is subject to the attacks of a Tenthredo, of which the larvæ—often amounting to as many as one thousand upon a single tree—devour its leaves at the beginning of summer. The Apple, again, suffers from the deposition of the eggs of another species in its fruit. And the Willow is subject to the attacks of many species, some of which devour its leaves, whilst others cause the production of galls by perforating its branches. The perfect Insects of this group are of moderate size, not exceeding an inch in length; some of them, however, are among the largest Hymenoptera inhabiting this country. Their flight is usually heavy, and is attended in the larger species with a humming noise; it seems, however, to be more agile in the hot sunshine. They come forth for the most part in the spring, having passed the winter in the pupa state; and they usually obtain their chief supply of food from the pollen or honey of flowers, especially those of the Umbelliferous tribe; some of them, however, attack and devour living insects which frequent the same plants. The ravages of these insects are restrained by the destruction of vast multitudes of *their* larvæ, through the agency of the Entomophagous, or parasitic section of this group; thus the *Lophyrus pini*, a Saw-fly which infests the Pine, is itself subject to the attacks of at least twenty parasites, of which fifteen are Ichneumonidæ.

688. The SIRICIDÆ bear a strong general resemblance to the preceding group, both in structure and habits; but they have a stronger ovipositor, which enables them to pierce not merely the soft substance of trees or young shoots, but hard timber. The larvæ produced from the eggs thus deposited, usually reside in the interior of trees, which they perforate in various directions; often causing great destruction of the Pine forests, of which the

largest species are inhabitants. When full grown, they form a slender silken cocoon, mixed with chips of wood, at the extremity of the burrow; and here they undergo their final transformation. The perfect Insects are among the largest of the order; they are remarkable for the very cylindrical form of their bodies, and for the humming sound which they make when on the wing.

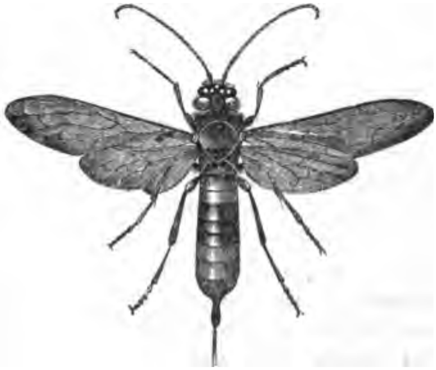

FIG. 384.—SIREX GIGANTEUS.

689. SECTION II.—In the section of ACULEATA ENTOMOPHAGA, the first family, that of CYNIPIDÆ, or *Gall-flies*, rather corresponds with the preceding in its general habits, and in the diet of the larvæ. These insects puncture, with their ovipositor, the surface of the leaves, buds, stalks, and young stems and roots, of various plants and trees; and they increase the aperture by means of the toothed edge, forming a kind of saw, with which the extremity of this organ is armed. In this aperture they deposit, besides the egg, a drop of fluid, which seems to be peculiarly irritating in its character; causing the production of tumours or *galls*, of various sizes, shapes, and colours; the solid interior of which becomes the food of the larva when hatched. It is a remarkable circumstance, that the very same tree should produce, on its different parts, galls of very different forms and of various degrees of consistency, according to the species of Cynips by which it has been punctured. The hardest is the common Gall-nut, which is employed in the manufacture of ink, and also, to a far greater extent, in the process of dyeing black (VEGET. PHYSIOL. § 399). This is produced in the Levant, upon a low-growing species of Oak, the *Quercus infectoria*. It has been recently ascertained, that the "apples of Sodom,"—

which are found on the borders of the Dead Sea, and which have been said "to appear outwardly tempting to the eye, but to turn to ashes on the lips,"—are nothing else than galls of a softer consistence, produced from the same Oak by the attacks of another species of Cynips. The "oak-apples," again, of our own country, are large galls found upon the young shoots; the leaves sometimes produce, besides the larger galls, a multitude of little spangled discs, of a reddish colour, which contain the larvæ of a small species of Cynips; the parts of fructification are sometimes attacked by a species, the galls of which hang on the catkins like a bunch of currants; and the root produces a large woody gall, inhabited by a species of Cynips, of which 1100 individuals have been found in a single gall. The Oak is by no means the only species of vegetable infected by these insects; but a larger number of Gall-flies appear to be restricted to it than to any other plant. The Rose is subject to the attacks of one species, which causes the flower-bud to be developed into a gall in a very curious manner.—An insect, considered as belonging to this family, deposits its eggs in the seeds of the most forward wild figs of the Levant. The modern Greeks, following a custom handed down to them by their forefathers, fasten several of these fruits among the later figs; and the insects escaping from them, covered with pollen, make their way into the unfertilised fruit, and thus contribute to its maturity (BOTANY, § 673). This operation is termed *caprification.*

690. The family of ICHNEUMONIDÆ may be regarded as peculiarly characteristic of the Entomophagous section. The female Ichneumon deposits her eggs, by means of her sharp-pointed ovipositor, only in the bodies of other insects,—chiefly the caterpillars of Lepidoptera, or the larvæ of the Phytiphagous section of Hymenoptera. Some of them have a very long ovipositor, which is used to insert the eggs into the bodies of Caterpillars that live beneath the bark, or in the crevices of wood; whilst those in which this instrument is short, place their eggs in or upon the bodies of caterpillars, to which they can obtain easier access. They do not confine themselves to these situations, however; but employ for the same purpose the eggs or

pupæ, still preferring the larvæ when they can meet with them. The young Ichneumons, when hatched as footless grubs,—sometimes in considerable numbers in the body of one caterpillar,—devour only the fatty parts, which are not absolutely essential to life; and the animal they infest may continue to exist for some time, thus affording them a continued supply of nutriment; but when the Ichneumons are ready to undergo their last metamorphosis, they either pierce the skin and escape, or else they kill their victim, and perform their changes within its body. The perfect Ichneumons feed solely upon the juices of flowers, and fly about with considerable agility in search of their nutriment, or of proper situations for the deposition of their eggs. It is in the genus *Pimpla*, that the ovipositor attains its greatest development, its length being in some exotic species as much as three or four inches; when not in use, it is inclosed in two long channelled filaments, which unite to receive it like a sheath. This family is extremely numerous. Probably more than 3000 species exist in Europe alone; and the number peculiar to other parts of the globe may fairly be reckoned as at least equal. Scarcely any tribe of Insects is free from their attacks; although, as already stated, the Lepidoptera are the chief sufferers. In restraining the multiplication of many Insects, which commit great injury against the Agriculturist, the Ichneumonidæ render essential service to Man; and there is no mode in which they can be said to do him any counteracting injury.

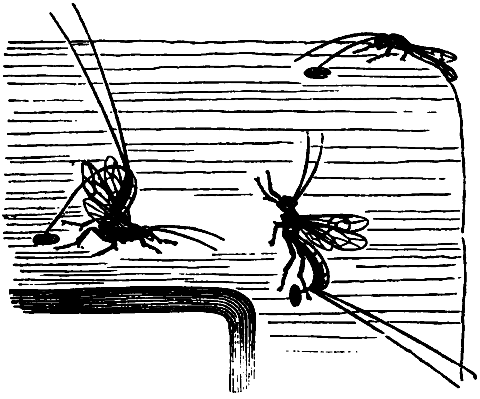

FIG. 385.—PIMPLA MANIFESTATOR, DEPOSITING ITS EGGS.

691. The family CHALCIDIDÆ, or *Chalcis* tribe, is composed of a great number of parasitic insects, distinguished by their generally very minute size, (their length seldom exceeding a line or two,) their brilliant metallic or variegated colours, and their nearly veinless wings. Like the Ichneumonidæ, they are all parasitic upon other insects in their early states; the majority infesting the larvæ and pupæ; but some, from their minute size, being reared within the eggs of other insects. They are especially destructive to Lepidoptera; but they will also attack the species of most of the other Orders. Not unfrequently they deposit their eggs in various kinds of galls, formed by the agency of the preceding families; and their progeny, when hatched, attack and subsist on the larvæ inclosed within: and there are some species, whose larvæ are parasitic upon those of other parasitic insects.—Lastly, the CHRYSIDIDÆ, or *Ruby-tailed Flies*, constitute a small group, distinguished by having the abdomen attached to the thorax by a short peduncle or foot-stalk, and composed of only from three to five segments,—the remainder being formed into a tubular apparatus, capable of being drawn together or extended like a telescope, and having a minute sting or ovipositor at its extremity. These insects, although but of small or moderate size, are amongst the most splendid of our native species; being adorned with brilliant metallic tints,—usually blue and green on the head and thorax, and a fiery copper-colour or ruby on the abdomen; hence they have been termed the humming-birds amongst insects. They may be observed during the hottest sunshine, flying and running with great vivacity over walls, palings, sand-banks, and occasionally upon flowers (especially those of the Umbelliferæ) and leaves. Their economy has not been fully made out; but there is reason to believe that the females do not insert their eggs in the bodies of other insects, but take an opportunity of depositing them in the nests of the different Wild-Bees and other Hymenoptera, during the period when the latter are provisioning their nests for the support of their own progeny; which is thus starved by the intruder, whose voracity is such as to require the whole supply of food that had been prepared for the legiti-

mate occupiers of the nest. In this habit, these insects closely resemble the Cuckoo (§ 351). In many points of structure, the Chrysididæ bear a strong resemblance to the Aculeate Hymenoptera; and they may be considered as intermediate between the two great divisions of the Order.

692. Section III. ACULEATA PRÆDONES. The Hymenoptera of the Aculeate division may be usually distinguished from the Terebrantia, by the mode in which the abdomen is united to the thorax. In the *borers*, it is in general closely jointed to it,—a structure which is evidently necessary for providing the ovipositor with the requisite strength; whilst in the *stinging* Hymenoptera it is usually connected by means of a peduncle or foot-stalk, which is often (as in the Wasp) extremely slender, and of which the first appearance is seen in the Chrysididæ, as just now mentioned.—The *Predaceous* subdivision of this group contains several families; of which the most important only will be noticed in detail.

693. The CRABRONIDÆ, LABRIDÆ, BEMBECIDÆ, SPHEGIDÆ, SCIOLIDÆ, and MUTILIDÆ, may all be considered under one general description; they form a group, which may be termed, from their peculiar habits, that of *Fossores*, or Diggers; and they are commonly known as *Sand* and *Wood-Wasps*. They are solitary in their mode of life, and consequently no neuters exist among them. In general the females excavate cells in the ground, or in posts, timbers, &c.; in which they deposit—together with their eggs—various larvæ or perfect insects, and (in some species) even spiders, which are destined for the support of their progeny when hatched. Occasionally the insects composing this store are first stung to death; but sometimes they are only slightly stung, and are finally killed by the larvæ when they come forth from their eggs,—being in this manner rendered powerless, whilst their bodies are prevented from decomposing. The perfect insects are generally very active, and fond of the nectar of flowers, especially those of the Umbelliferous tribe. They delight in the hottest sunshine, flying and running over sand banks exposed to the mid-day sun, and keeping their wings in constant agitation; some of the tropical

species are among the largest of the order, and their sting is very severe. The Sand-burrowers excavate their nests, by means of powerful brushes, with which their legs are furnished; whilst the Wood-burrowers use for this purpose their strong broad mandibles, which are provided with tooth-like projections.

694. The next family, that of FORMICIDÆ, is composed of the well-known and singularly interesting tribes of *Ants* (the White Ants, improperly so called, belonging however to the preceding order); which are distinguished from all the Hymenoptera previously described, by their habit of residing underground in numerous societies, and by the existence of *neuters* among them, by which class the labours of the community are chiefly performed. The males and females, which constitute but a small proportion of each community, are alone furnished with wings; the former are the smallest. The neuters are somewhat smaller than the males, and for the most part resemble the females in conformation; but the thorax is smaller, not having to give attachment to wings. The nests of Ants are differently constructed in the different species, but all are very curiously and regularly arranged; some account of them will be given hereafter. The males and females leave the nest, as soon as they have acquired their wings; and go forth together into the air. The males soon die, without entering their former abode. Of the females some return, and deposit their eggs in the original nest; whilst others go to a distance, and become the foundresses of new colonies: they, too, lose their wings at this period, sometimes stripping them off with their own feet, in other instances being deprived of them by the neuters.—These last not only construct the nest, but most carefully tend the young grubs; supplying them with food, moving them on fine days to the outer surface of the nest to give them heat, and carrying them back again at the approach of night or bad weather, and defending them when attacked by enemies. The winged Ants having all perished at the commencement of the cold weather, the neuters only survive the winter. Some of them are larger and rather differently formed from the rest, and appear to be the *soldiers* of the com-

munity;—not only defending their own nests against attacks, but actually making war upon the nests of other species of Ants (as will be hereafter detailed), and keeping their captives in slavery. Ants are well known to be extremely fond of saccharine matters; and they seem greatly to relish the fluid which exudes from the bodies of Aphides and Coccidæ (§ 719, 720). Some species even collect Aphides into flocks, and keep them, as it were, in pastures; which they conneet with their nests by means of galleries, excavated along the stems and branches of trees; and they protect the eggs of these insects in their own nests, especially in bad seasons.

695. The family of VESPIDÆ, or *Wasps*, is distinguished from the other Hymenoptera, by the wings being folded when at rest, throughout their entire length. In general these insects are *social;* the communities, however, being small. In such cases, there are *neuters*, or individuals of neither sex; but these are not destitute of wings. There are also some *solitary* Wasps (whose habits resemble those of the Fossores, whilst their general structure is more conformable to that of the Social Wasps), among which no neuters exist.—The best-known of the *Social Wasps*, such as the Common Wasp of this country, construct their nests with bits of wood, bark, &c., which they separate with their jaws and reduce to a pulp; and this pulp, when expanded and dried, forms a paper-like substance. With this are built layers of hexagonal cells, one row being joined to the under side of another. The top row is attached in some species, merely to the under side of a branch, or to the roof of a slight hollow, by which it may be in some degree protected; but in other species, the whole comb is enveloped in a covering, formed by several layers of the same paper-like substance, with one or more apertures (Fig. 387; and ANIM.

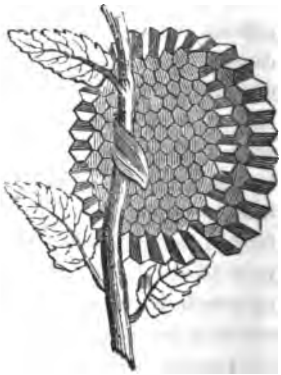

FIG. 386.—NEST OF POLISTES.

Physiol. Fig. 267). Wasps feed in their perfect state upon insects, meat, fruit, &c.; and nourish their young with the juices of those substances. A Brazilian species stores up an abundant provision of honey.—The nests of the Solitary Wasps are formed of earth; they are sometimes concealed in holes of walls, in the earth, or old wood; and sometimes they are fixed to plants. The parents store them with insects or caterpillars, which they have previously wounded with their stings. These nests contain a succession of cells, in each of which a single egg is deposited.

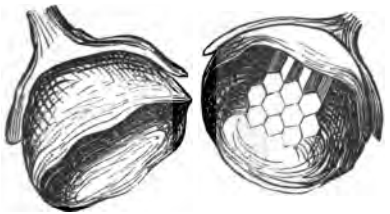
Fig. 387.—Nest of Vespa Holsatica.

696. Section IV. The Hymenoptera belonging to the *Melliferous*, or honey-collecting divisions of the Aculeata, are known by the peculiar conformation of the hind-feet; of which the first joint is compressed and extended into the form of a square plate, and provided on the inside with brush-like tufts; these organs are employed for the purpose of collecting and carrying the pollen of flowers, which is destined for the nourishment of the young.—All the insects of this tribe are commonly known by the name of *Bees;* but the tribe, like that of Wasps, contains two different groups,—in one of which the species are all solitary, and there are only two kinds of individuals—males and females—in each; whilst the others mostly live in societies of greater or less extent, but are chiefly distinguished from the former by certain peculiarities in the structure of the mouth.

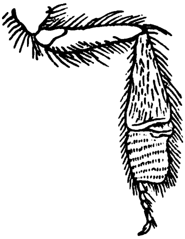
Fig. 388.—Hind Leg of Working Bee.

697. Of the *Solitary Bees*, which constitute the family ANDRÆNIDÆ, there are many curious varieties; some of which go under the names of Mason, Carpenter, and Upholsterer Bees, from the materials on which they respectively work; the first

agglutinating bits of sand or gravel, by means of a viscid saliva, and constructing with these a regular edifice ; the next excavating wood by means of their powerful jaws ;—and the last constructing their cells out of pieces of leaves, which they cut into the requisite form with surprising dexterity. The purpose of these operations is, in all instances, to form a series of cells ; in each of which an egg is deposited, with a supply of pollen-paste for the nutrition of the larva.

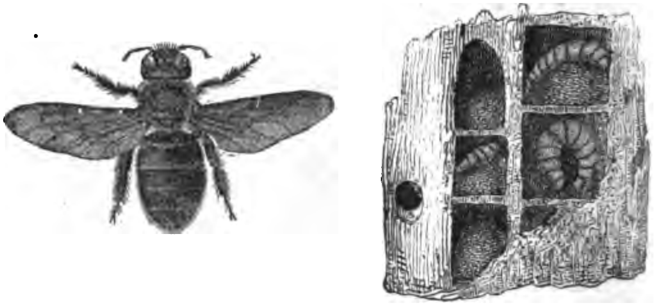

FIG. 389.—XYLOCOPA, OR CARPENTER BEE; AND NEST.

698. Of the *Social Bees*, or APIDÆ, there are two principal groups ; the first consisting of the *Humble-Bees* or *Wild-Bees ;* and the second of the *Hive-Bees.*

699. The *Bombi*, or *Humble-Bees*, of which there are many species in this country, live in curious habitations, which are sometimes excavated at a considerable depth in the ground, and sometimes built upon its surface, beneath stones, &c. The societies consist, in some species, of about fifty or sixty individuals ; in others of as many as 200 or 300. They contain three

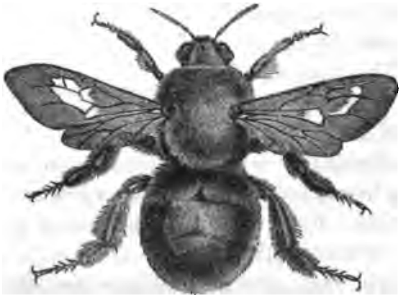

FIG. 390.—BOMBUS.

kinds of individuals,—males, females, and neuters: of these the females are the largest, and the neuters the smallest. The females alone survive the winter; and they employ the first fine days in spring to commence their nests, which they very quickly excavate, and supply with a mixture of honey and pollen for the nourishment of the first brood. This consists exclusively of *workers* or *neuters;* which, after having undergone their transformations, assist in the labours of the nest,—both by the construction of new cells, the collection of food, and the rearing of the larvæ. It is not until the autumn, that the males and females are produced. The former proceed from eggs laid by females, so much smaller than the rest, that they have been mistaken for workers. At the commencement of winter, all but the larger females die; these remain in a sort of chamber distinct from the rest, rendered warm by a carpeting of moss and grass; but without, as it would appear, any supply of food.

700. It is in the *Hive-Bees*, that the arts of construction, and the union of individuals in societies, are exhibited in the most remarkable manner. These societies contain but a single perfect female, commonly termed the Queen,—several hundred males, which are known as Drones,—and about twenty thousand Workers or Neuters. It is by the latter that all the labours of the hive,—the construction of the combs, the collection of food, and the nourishment of the larvæ,—are performed. The accompanying figures exhibit the relative sizes and aspects of these three kinds. The wax of which the comb is constructed, is secreted by the insects themselves, in little scales, which work out between the segments of the abdomen. These are taken up and kneaded by the jaws, and applied in the proper place. The cells are for the

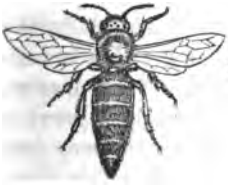

Fig. 391.—Queen Bee.

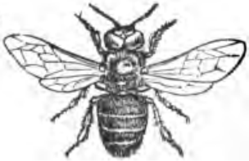

Fig. 392.—Drone Bee.

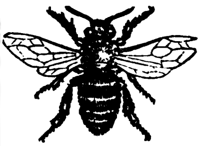

Fig. 393.—Neuter Bee.

reception of the eggs, of honey and of the pollen of flowers mixed with honey, into a paste known as *bee-bread.* This food is not deposited in the cells with the eggs; but is supplied to the larvæ by the workers, which tend them most assiduously. The honey is stored up for the support of the adults through the winter; a considerable proportion of the Neuters surviving, as well as the Queen, when the supply of food is sufficient. The Drones are killed at the end of the summer, by the stings of the workers, being themselves unprovided with any means of defence. The eggs are laid in the central part of each comb, which is the warmest situation; those which are to produce Drones have cells constructed for them, which are rather larger than the rest; and those from which Queens are to be reared, termed royal cells, are much larger and of different form. When so many young Bees are produced, that the hive is over-peopled, colonies are sent forth with young queens in search of another habitation. Further details on the economy of Bees have been elsewhere given (ANIM. PHYSIOL. §§ 712—716); and others will be found in a later part of this volume.

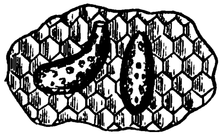
FIG. 394.—ROYAL CELL.

ORDER V.—LEPIDOPTERA.

701. This Order, characterised, as formerly stated, by the downy covering of the wings, contains some of the most beautiful forms of the whole class, as well as some of the largest. The number of species it comprehends, is probably as great as that of any other Order, except the Coleoptera; and may probably rank as about one-fifth or one-sixth of the whole class. All the insects of this Order are commonly ranked as *Butterflies*, *Moths*, and *Sphinges* or *Hawk-moths;* and whilst they are most readily distinguished from all others, there is so much general resemblance among themselves, that the difficulty of classifying

them is often considerable. The possession of scales upon their wings is not altogether peculiar to them, for they are found upon the wings and bodies of other insects; but it is only in these, that the wings are covered with such complete layers of them. The scales are generally of somewhat oval form, terminating at one end in a kind of stalk, by which they are attached to the membrane of the wing; and on this they are arranged in rows, overlapping each other like tiles on a roof. They may be easily rubbed off with the finger, and the bare membrane is left, which is then seen to correspond with that of the wings of other insects. The number of scales covering the wings of the Silkworm Moth, has been estimated at about 400,000; it is entirely to these that the colours of the wings are due, which are frequently so gorgeous in this Order. In a few species, the wings are partially, or even almost entirely destitute of scales; but the structure of the mouth, and their alliance in general characters with other species, leave no doubt that they belong to this Order. Of the peculiar adaptation of the mouth of the Insects composing this Order, for *suction*, mention has been already made (§ 616); and they are therefore placed at the head of the Haustellate or Suctorial group, as the Coleoptera are at the head of the Mandibulate insects. Of their metamorphosis, also, an account has been given; and it now only remains to describe some of the peculiarities of the larvæ and pupæ of this Order.

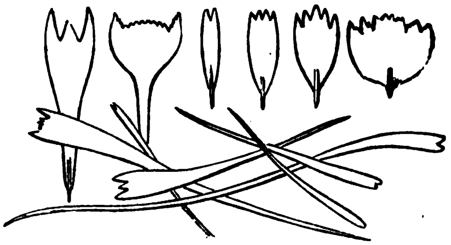

FIG. 395.—FEATHER-SCALES OF THE GOAT-MOTH.

702. The first three segments of the body, in the Lepidopterous larvæ, have each a pair of simple, short, and jointed feet; which are the rudiments of those of the perfect insect. Behind these are a variable number of temporary appendages, called *pro-legs*, which are thick, short, fleshy tubercles, armed at their extremity with a great number of minute hooks; and furnished with powerful

muscles. There are usually five pairs of these—four of them succeeding the true legs, and another proceeding from the last segment of the body. Those possessing pro-legs on nearly every segment, crawl upon all the feet at once, after the manner of the Myriapoda; but those which have only a small number of pro-legs adopt a different method. They seize fast hold of the objects on which they are stationed, with the six true legs at the fore part of the body, and then elevate the intermediate segments into an arch, until they bring the pro-legs behind close to the others; they then disengage the true feet, and retaining hold with the pro-legs, they thrust the body to its full length, and then recommence the same manœuvre, which they execute very quickly. They are called, from this circumstance, Loopers or Geometers. Many of them resemble small

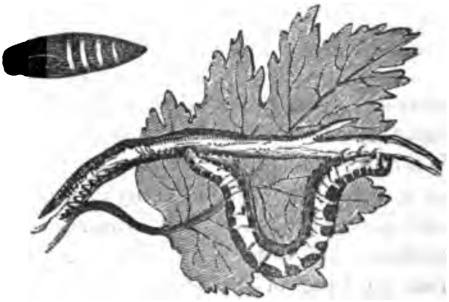

FIG. 396.—CATERPILLAR AND CHRYSALIS OF MAGPIE MOTH.

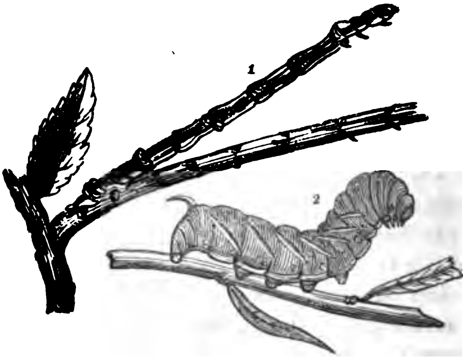

FIG. 397.—1. CATERPILLAR OF SWALLOW-TAILED MOTH (*Curapteryx Sambucaria*).
2. CATERPILLAR OF PRIVET HAWK-MOTH (*Sphinx ligustri*).

pieces of stick in their forms and colours; as well as in their mode of occasionally standing fixed to twigs, by their hind legs only, for a great length of time. Such an attitude requires a great amount of muscular force; and we find that the muscular system of these Caterpillars is very complicated and highly developed (Fig. 398). It was stated by Lyonnet, who devoted many years to the study of the anatomy of the larva of the Goat-moth, that this contains 4041 distinct muscles.

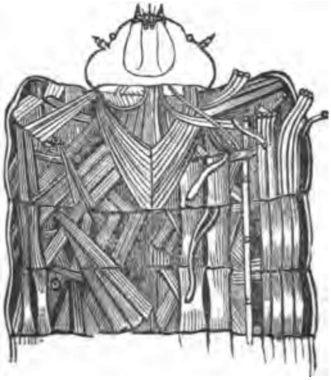

FIG. 398.—DORSAL MUSCLES OF THE ANTERIOR SEGMENTS OF THE CATERPILLAR OF *Cossus*.

703. The greater number of Caterpillars are vegetable-feeders, most of them confining themselves to the leaves of plants; and the correspondence between the development of the leaves and flowers of plants on the one hand, with that of the Caterpillars and Butterflies which are respectively to feed upon them, cannot but strike every one as a beautiful example of creative foresight.—But there are some Caterpillars, which are adapted to feed upon such flowers, as come forth early in the year; and others attack seeds, roots, and even the woody portion of the stem. Moreover, there are a few which live in this state upon animal matter, such as wool, hides, leather, and fat. Many can digest a considerable variety of alimentary materials; whilst there are others that can only find support on some one kind,—the leaves of a particular species of plant for example. The habits of Caterpillars are extremely various. Some burrow into the substance of

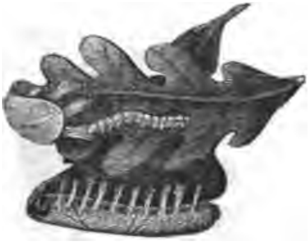

FIG. 399.—NEST OF TORTRIX.

leaves, in which they excavate galleries; others envelope themselves in the membrane of the leaf itself, which they roll together and attach by threads,—as seen in Fig. 399, representing the nest of the larva of *Tortrix viridissima* (a small nocturnal Butterfly), which is constructed upon the leaves of the Oak. Many construct cases or sheaths, either fixed or portable, by agglutinating several substances together,—as is done by the larva of the common Clothes'-Moth; and there are some that live in societies, dwelling together under a tent of silk, which they spin in common, and which serves to defend them from the inclemency of the weather.

704. The Imago, or perfect Insect, when it throws off its last envelope and comes forth into the air, of which it is henceforth to be one of the gayest inhabitants, is not altogether perfect, although capable of very soon becoming so. The wings appear at first very slightly developed, and sometimes even hang loosely at the sides; and it is not until the animal has injected their tracheæ with air,—by taking several full inspirations and then forcing it into these passages,—that they become expanded so as to serve for flight. From that period the body is supported by them, during by far the largest proportion of their active state; the legs being weak and used only to rest upon, and one pair being sometimes undeveloped (Fig. 401).

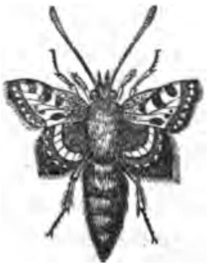

FIG. 400.—TORTOISE-SHELL BUTTERFLY JUST EMERGED FROM THE CHRYSALIS.

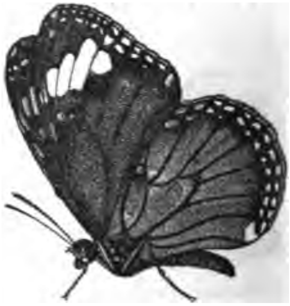

FIG. 401.—DANAIS PLEXIPPA.

705. The Lepidopterous insects are divided into three

sections; which differ alike in their conformation and habits. These are,—I. The DIURNA, *Diurnal* Lepidoptera, or *Butterflies*, which may be at once distinguished by the vertical position of the wings during repose;—II. The CREPUSCULARIA, or *Twilight* Lepidoptera, commonly known as *Hawk-Moths*, in which the wings are horizontal in repose, and the antennæ thick and club-shaped;—and III. The NOCTURNA, *Nocturnal* Lepidoptera, or *Moths*, whose wings are also horizontal or inclined in repose, but whose antennæ are more slender, tapering gradually from the base to the point.

706. Section I. DIURNA.—The first section corresponds with the Linnæan genus *Papilio;* which is now, however, very much subdivided. The Butterflies are distinguished from the other Lepidoptera by the brilliancy of their colouring, and by the beauty of the under as well as the upper side of the wings. Their Caterpillars have usually sixteen feet; and their Pupæ are nearly always destitute of any silken envelope, and are attached by the tail. The Pupa of nearly every Butterfly of this group is ornamented with golden spots; from which circumstance the name Chrysalis is derived: this term ought, therefore, to be limited to the Pupa of the Butterflies; but it is now in such general use, as applied to all Pupæ, that it is undesirable so to restrict it, and the term *Aurelia* (which means in Latin what Chrysalis does in Greek) is now employed by Entomologists to designate *these* Pupæ. The antennæ of Butterflies are sometimes knobbed at their extremities, sometimes of the same thickness throughout, and sometimes taper gradually from base to point. To the genus *Vanessa*, which is distinguished by the abrupt termination of the antennæ in a short knob, belong several of

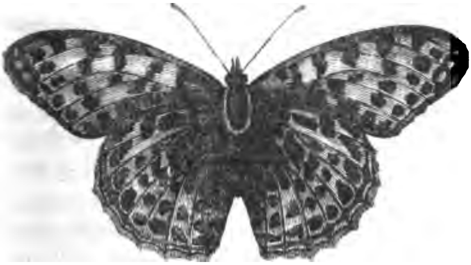

FIG. 402.—ARGYNNIS PAPHIA.

the most beautiful of the British Butterflies;—such as the Peacock (Fig. 403), the Painted Lady, the Camberwell Beauty, the Red Admiral, the Tortoise-shell, and others. The subdivisions of this Section bear so strong a resemblance to each other in structure and habits, that it is not requisite to describe them more minutely.

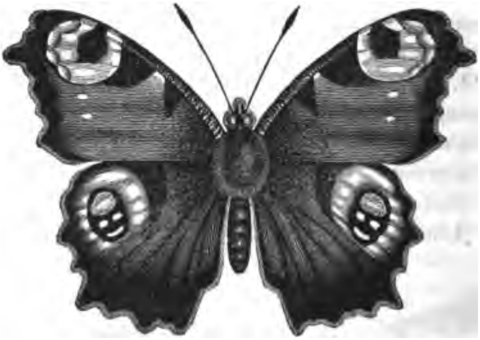

FIG. 403.—PEACOCK BUTTERFLY.

707. Section II.—The CREPUSCULARIA, or *Hawk-Moths*, correspond with the Linnæan genus *Sphinx;* which derives its name from the peculiar attitudes, resembling that of the sculptured Sphinx of antiquity, into which the larva sometimes throws itself (Fig. 397, ²). Although the Lepidoptera arranged under

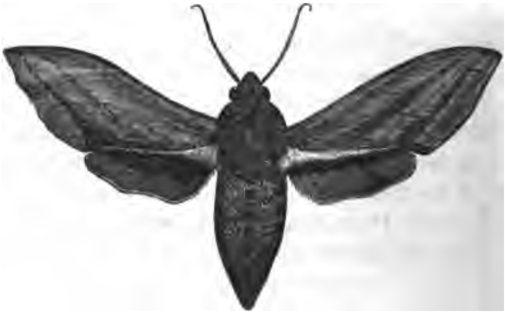

FIG. 404.—SPHINX OF THE VINE.

this division on account of their correspondence in structure, are mostly twilight-fliers, this is not the case with all; for there are some which come abroad in open daylight, and suck the juices of flowers with their long trunks, whilst the sun is brightly illumining their wings. These species are observed to be more brilliantly coloured than the rest; the body and wings in most of the Sphinges having a dull, brownish-grey aspect, like that of many Owls, whose habits are similar. The wings are more downy in appearance than those of Butterflies, as if the scales did not lie so closely upon one another. The larvæ of the Hawk-Moths have always sixteen feet; and their pupæ are either inclosed in a cocoon, or bury themselves in the earth. The perfect insects make a loud humming noise in their flight.—One of the most remarkable of this group is the *Acherontia atropos*, Death's-Head-Moth (Fig. 312), which is distinguished by the skull-like patch on the back of the thorax, as well as by the squeaking sound which it emits. In consequence of the peculiar aspect of the body, the sudden appearance of this insect in large numbers has been commonly regarded as ominous of evil. It is a great enemy to Bees, and enters their hives, devouring their honey, and alarming the inhabitants so much, that they keep aloof from it instead of attacking it, although it has no means of defence.—The *Sphinx stellatarum*, or Humming-bird Hawk-Moth, commonly known under the name of "Bee-bird," is one of the most beautiful of the diurnal species; and is remarkable for the loudness of the sound which it produces, when feeding self-poised upon its wings, by means of its long proboscis, which it inserts into the cups of even the narrowest tubular flowers. It might thus be almost regarded as the representative, in our own climes, of those feathered beauties after which it is named, that delight the eyes of the observer of Nature in tropical regions.

708. Section III. The group of Nocturna, or *Moths*, is by far the most extensive of the order, and includes the largest species. In their general aspect, Sphinges and Moths are somewhat alike; but they may be at once distinguished by the form of the antennæ, which taper in the latter from base to point.

Many of them have no distinct trunk; and in some species the females are almost, or altogether, without wings. Sometimes the wings can be rolled round the body; and in a few instances they fold longitudinally, like a fan. The greater part of these Lepidoptera fly by night, and their colours are usually dull. Their Caterpillars vary as to the number of their legs, from ten to sixteen; their pupæ are of rounded form, and almost always spin a cocoon. The large number of species belonging to this section, and the general similarity of their form, make their classification a matter of some difficulty. They have been divided into ten families; of which it will be sufficient here to notice the most important.

709. The first family, that of HEPIALIDÆ, contains two interesting genera, *Hepialus* and *Cossus*. The Moths of the former are commonly termed *Swifts*, from the rapidity of their flight, which takes place during the twilight; the sexes vary considerably in appearance and structure,—the male of one species, which frequents the Hop, being pure white, whilst the female is yellow, with darker markings. The male is commonly known as the *Ghost-Moth*, from his colour, and from his habit of hovering with a pendulum-like motion, over one spot (often in churchyards), where the female is concealed. The genus *Cossus* contains the *Goat-Moth*, one of the largest of British Lepidoptera; which has received its common name from the goat-like character of the strong scent emitted by the larva. This larva feeds upon the wood of willow-trees, which it perforates in every direction, and thus so greatly weakens the trees, that they are often blown down with the first strong wind. It was this larva, which was so laboriously dissected by Lyonnet (§ 702); and his researches were continued upon the pupa and imago, so as to constitute the most elaborate and complete account of the anatomy of any Insect, that has been yet given to the world.

710. The family of BOMBYCIDÆ consists of Moths allied to that of the common *Silk-worm*. The pupæ are inclosed in cocoons of pure silk, frequently of very firm texture; and they are rarely subterranean. The prevailing hues of these Moths

are grey or fawn colour; and many of the larger species have the wings ornamented with eye-like spots (Fig. 405). This tribe contains the largest species of Lepidoptera. The *Saturnia pavonia major*, found in France, has been seen to attain the breadth of five inches across the wings; and the *Saturnia pavonia minor*, or Emperor Moth of this country (Fig. 405), attains the breadth of 3½ inches. Many of this genus are remarkable for the contrivances they adopt for security in the Chrysalis state; and among the most so is the *Saturnia promethea* (Fig. 406), an

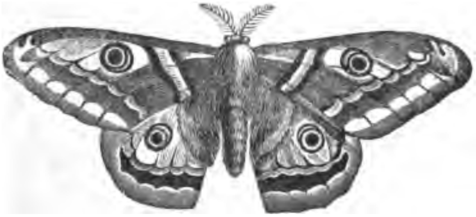

FIG. 405.—EMPEROR MOTH.

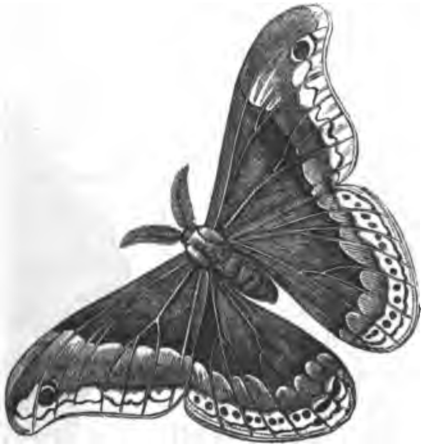

FIG. 406.—SATURNIA PROMETHEA.

American species, which, previously to spinning, draws together the sides of a leaf (within which it afterwards forms its cocoon), and fastens its stalk to the stem by a strong silken web (Fig. 407). The genus *Bombyx* is one of great interest and importance, as containing the *Bombyx mori*, whose larva furnishes all our silk; as well as many other species. Of these, some much resemble a bundle of dead leaves, both in colour and form, when their wings are closed; such is the *Bombyx quercifolia*, or Oak-leaf Moth (Fig. 408). The Caterpillars of another species of Bombyx are remarkable for their curious habits. They live in societies on the leaves of the oak; and spin, when young, a kind of silken tent, divided within into cells. They may be seen to issue from it in the evening in a procession, — one of them, which seems to act as a guide, advancing at the head,—two then following,—then three,—then four,—and so on, each rank containing one more than the preceding one. Hence they have been called *processionary* caterpillars. Each spins a separate cocoon; but they are united in regular apposition, being laid side by side against each other.

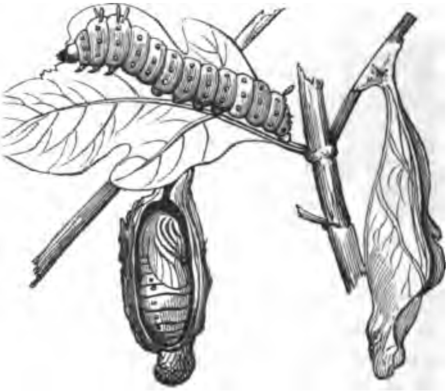

FIG. 407.—CATERPILLAR, LEAF-COCOON, AND CHRYSALIS OF THE PROMETHEUS MOTH.

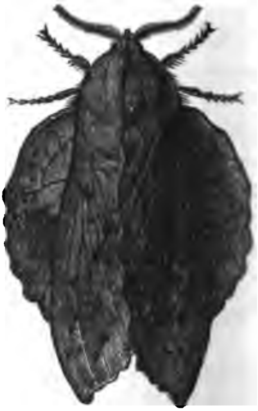

FIG. 408.—BOMBYX QUERCIFOLIA.

711. The family NOCTUIDÆ contains a great proportion of

the larger sombre-coloured night-flying Lepidopterous insects; and contains 400 British species, which bear a very strong resemblance to each other.—The family Geometridæ, so named from the peculiar mode of progression of its Caterpillars (§ 702), is nearly allied to the preceding; but the Moths it includes are less exclusively nocturnal, and are more brightly coloured. To this family belongs the common *Magpie Moth* (Fig. 409), whose larva and pupa have been already represented (Fig. 396); also the *Swallow-tailed Moth*, and many other well-known species.—The Tortricidæ constitute a numerous group, composed of minute and usually dull-coloured Moths, whose larvæ are extremely destructive to vegetation. One of these, known as the Codling Moth, is one of the most destructive enemies to the Apple crops of this country; laying its eggs in the eyes of the newly-formed fruit, within which the larva feeds, its presence being only indicated by the premature falling off of the fruit.—Another species does great damage to our apricot trees in the early spring, by tying the young shoots together with threads, so firmly that their growth is stopped, and by devouring the young blossom-buds. Another species (Fig. 399) feeds upon the Oak, which in certain years it totally strips of its foliage: its numbers

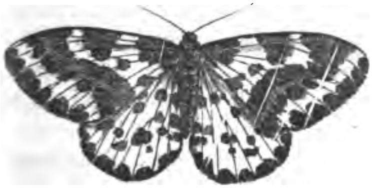

Fig. 409.—Phalæna grossulariata.

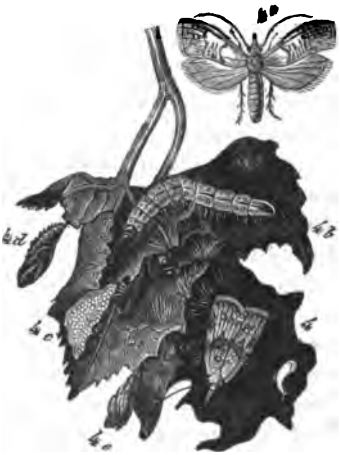

Fig. 410.—Pyralis vitis.

4, Male; 4 *a*, Female; 4 *b*, Caterpillar; 4 *c*, Eggs; 4 *d*, 4 *e*, Pupæ.

being so great, that when the branches of that tree are sharply beaten, a complete shower of these moths is dislodged. And another commits great havoc in our gardens, by eating the young leaves and buds of the roses; the caterpillar feeding within the bud, from which, when disturbed, it lets itself down by a thread. One of the most destructive insects of this family is the *Tortrix vitana* (the *Pyrale* of French Entomologists); whose larvæ commit extensive ravages in the Vineyards of some parts of France, where they occasionally appear in very large numbers, devouring and tying together the leaves, and preventing the development of the grapes, by surrounding them with the silken threads of which they make their cocoons (Fig. 410).

712. The family TINEIDÆ contains those little Moths, commonly termed *Clothes'-Moths*, whose larvæ are so injurious to woollen stuffs of every kind, as well as to furs, skins, feathers, and other objects of natural history, upon which their voracity is exercised. They use the same materials also for the construction of their moveable cases or sheaths; which they enlarge with the increasing size of their bodies, both by adding to their extremities, and by slitting them along and inserting a new piece, so as to increase their diameter. In these tubes they undergo their metamorphoses, after closing the orifice with silk.—The larvæ of the genus *Galleria* infest Bee-hives, feeding upon honey, forming galleries in the honeycomb, and enveloping the bees in their silken webs, sometimes to such an extent as to destroy the community.

713. The FISSIPENNÆ, or *Plumed Moths* (Fig. 304) constitute a small group, distinguished from all other Lepidoptera by the singular division of the wing into branches or rays, of which each pair has from two to six; these are most beautifully fringed at their edges, and much resemble the feathers of Birds. They are composed of the nerves alone, without any intervening membrane; this last seeming to have been transformed into the fringe. The Plumed Moths are of small size; some of them are diurnal and brightly-coloured; others are twilight-fliers, and of a duller aspect. Some species have the power of folding up the wings like a fan; so that, when closed, they present the appearance of a single broad ray.

714. This is probably the place in which the small Order STREPSIPTERA should be introduced; although the insects composing it depart so widely from the general type, that it is difficult to say to what orders they are most nearly allied. They are few in number; and are parasitic in their larva state upon other insects, especially the solitary Bees belonging to the family Andrænidæ. The name of the Order, which means "twisted wings," has reference to certain curious appendages, that look as if they had been twisted, which are seen in front of the wings; these appendages are attached to the second segment of the thorax, whilst the wings (of which there is only one pair) proceed from the third; hence they are to be regarded as the altered rudiments of the *anterior* pair of wings, in the same manner as the *balancers* of the Diptera are to be considered as the rudiments of the *posterior* (§ 724). The most remarkable feature in the organisation of these insects, is the absence of any opening at the mouth; although it is furnished with appendages in some degree resembling those of the Lepidoptera. The eyes are large and prominent, being mounted on footstalks as in many Crustacea. The antennæ are of singular form, being usually furnished with an internal branch or projection nearly as long as the antennæ itself. The wings are large, and folded in a fan-like manner; when in motion they make a buzzing sound, which is considerable in proportion to the size of the animal. The third segment of the thorax, to which they are attached, is developed

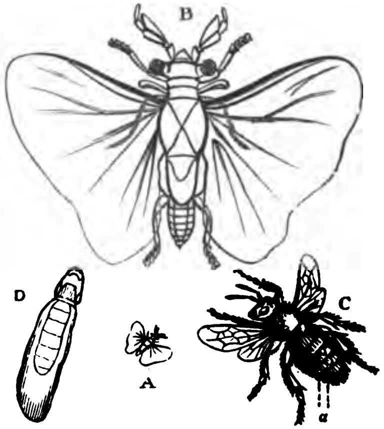

FIG. 411.—A, Stylops Dalii, nat. size; B, magnified; C, Andrena, with the heads of two of its larvæ exserted between the abdominal rings, *a*; D, larva extracted and magnified.

to an extraordinary size in proportion to the rest of the animal. The larvæ appear to feed upon the fatty matter in the bodies of the Bees and Wasps, on which they are found, without injuring their vital parts; and their production does not seem to cause the death of the animals they infest. When full grown, their heads may be seen projecting between the segments of the abdomen of the Bee (Fig. 411, *a*). Here, too, they undergo their metamorphosis into the pupa state; remaining still inclosed in the larva-skin, and bursting through both the larva and pupa cases, to make their way forth as perfect insects. No distinct mouth has been discovered in the larva, and its mode of obtaining nourishment is unknown. Many points in the economy of these singular insects are still uncertain; especially all that concerns their reproduction. All the specimens yet discovered appear to be males; and it has not been yet ascertained when and how the eggs are laid, or at what stage in the growth of the animals infested by them, the parasites first make their appearance.

ORDER VI.—HOMOPTERA.

715. THE Insects of this Order are distinguished from all others which have, like them, the mouth adapted for suction, by possessing two pairs of wings, usually composed of a firm membrane, and not covered by scales; and by having the anterior pair, whatever may be their consistence, of the same substance throughout, and roof-like when folded. They present many curious anomalies both in structure and habit; so that it is difficult to assign any general character that shall include them all. It is in the structure of the mouth that there is the greatest agreement; this is adapted for suction, the tongue being elongated and channelled like a gutter, and being surrounded by delicate lancet-like organs, with which the tissues of plants are pierced. All the Insects of this group subsist on vegetable juices; and some of them, from the amount of damage they commit, are very injurious to the cultivator. Some of the females are furnished with an ovipositor, provided with several

toothed saws; and with this they make incisions into the leaves and stems of plants. This Order may be divided into sections, like the Coleoptera, according to the number of joints in the tarsi. These sections are only three in number: in the first, TRIMERA, the tarsi are *three*-jointed; in the second, DIMERA, they are but *two*-jointed; and in the third, MONOMERA, they have but *one* joint.

716. Section I. TRIMERA. The three-jointed division of the Homoptera includes three families, the CICADIDÆ, or *Cicadas*, the CERCOPIDÆ, or *Froth-hoppers*, and the FULGORIDÆ, or *Lantern-flies*.—The CICADIDÆ are the largest of the Order; one species measuring between six and seven inches in the expanse of its wings. They are nearly all inhabitants of tropical or the warmer temperate regions; only one small species having been found in this country. They have large transparent wings, but are not very active in their habits; being generally found upon trees or shrubs, whose juices they suck. The female makes a succession of slits in the small twigs with her ovipositor, and deposits her eggs in these; the young larvæ soon quit their birth-place, however, and descend to the ground, where they increase in size and become pupæ. It is a species of *Cicada* inhabiting a kind of Ash, which, by puncturing it, causes it to discharge the sweet, slightly purgative, substance, that is known as Manna.—Of the peculiar sound-producing powers of the Cicadidæ, an account has been elsewhere given (ANIM. PHYSIOL. § 679). The ancient Greeks used the Pupæ and perfect insects as articles of food.

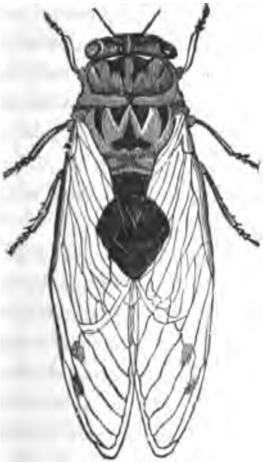

FIG. 412.—CICADA.

717. The FULGORIDÆ bear a general resemblance to the Cicadidæ, but are generally destitute of organs for producing

sound, and have the legs more adapted for leaping. Many of them are distinguished by a curious prolongation of the forehead, which sometimes equals the rest of the body in size. The shape of this projection varies extremely in the different species, which are numerous in many tropical regions. It is in it, that the luminous property of the *Lantern-fly* (Fig. 413) is said to exist; but the luminosity of this insect,—of which one species is a native of Guiana, and another of China,—is doubted by many naturalists, the evidence in regard to it not being sufficient. If it really exists, it is only at particular seasons. The Lantern-fly of Guiana seems to be an exception to the general rule, with respect to the absence of sound-producing powers in this Order; for it produces, from sun-set to sun-rise, a loud sound which has been compared with that of a razor-grinder at work.

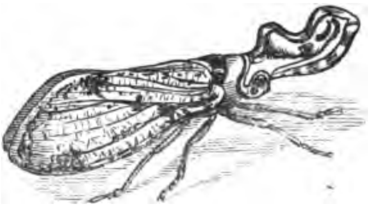

FIG. 413.—FULGORA LANTERNARIA.

718. The family CERCOPIDÆ consists of insects of small size; many of which are remarkable for the grotesqueness of the forms they assume. Several species are inhabitants of this country, and are known under the name of *Frog-hoppers*, from their leaping powers; or of *Froth-hoppers*, from their peculiar frothy secretion; or of *Cuckoo-spits*, from the supposed origin of this fluid. The most singular forms, however, are confined to the tropics; and examples of them are presented in the accompanying figures of two Brazilian species, whose curious appendages result from an extraordinary development of the first segment of the thorax. The insects of this family are often beautifully varied in their colours; they are constantly found upon plants, upon the juices

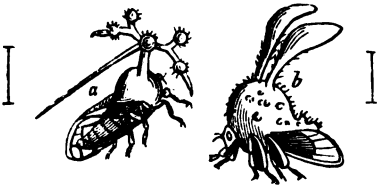

FIG. 414.—*a*, Bocydium globulare; *b*, B. cruciatum.

of which they subsist in all their stages; and some of them are employed by certain species of Ants, for the same purposes as the Aphides (§§ 694 and 719). The *Aphrophora spumaria* is one of the best known British species; its larva and pupa, resembling the perfect insect in almost every respect save the absence of wings, are found beneath a frothy exudation,— especially upon willow-trees; and the exudation is sometimes so abundant, from the large number of these animals, that persons walking beneath are wetted by the continual dropping of the fluid. A species nearly allied to this, inhabiting Madagascar, discharges a clear instead of a frothy fluid; and this in such quantities, that it falls to the ground in the middle of the day, when the heat is the greatest, in a continual shower.

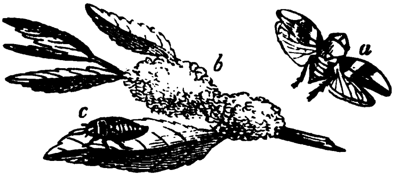

FIG. 415.—APHROPHORA SPUMARIA; *a*, imago; *b*, frothy secretion; *c*, pupa.

719. Section II. DIMERA. This section entirely consists of minute insects; of which the most remarkable family is that of APHIDÆ, or *Plant-Lice.* These live in great numbers upon the surface of plants of almost every description, and suck the juices, by means of their proboscis, from the young shoots, leaves, stems, and even roots. They greatly weaken its vigour, and often distort young shoots and leaves; some species cause little gall-like excrescences by the irritation they produce. From two horn-like processes at the posterior part of their bodies, a saccharine secretion exudes, of which Ants are very fond (§ 694); and it is either this fluid dropped on the adjacent leaves, or the extravasated sap flowing from the wounds made by the insects, which is known under the name of *honey-dew.* In many of the species of this family, a large proportion of the individuals never acquire wings; in which case the Pupa is not to be distinguished from the Larva or Imago; whilst at certain parts of the year, other individuals of the same species, and of both sexes, acquire wings. The wingless Aphides, which may be seen in the spring and early summer, are all females capable of producing

fertile eggs; and from these are reared the winged males and females, which are seen later in the season. Their rapidity of production is enormous; nine generations having been produced within three months, and each generation averaging 100 individuals. Hence it may be calculated that, from a single Aphis, 10,000 *million millions* may be generated in that short period. It is not surprising, then, that an immense amount of damage should be done by them, notwithstanding their very small size. Many of the *blights* so injurious to the gardener and the agriculturist, consist really of Aphides; although from the minuteness of the insects themselves, they frequently escape observation. The *Aphis Rosæ*, or Rose Louse, is one of those best known to the gardener; whilst the one most destructive to the property of the cultivator on a larger scale is the *Aphis Humuli*, or Hop Fly. Of the extent of its influence on the production of that vegetable, some idea may be formed from the fact, that the *duty* paid to the English government on its growth, has varied from 468,000*l*, to 15,400*l*. in different years, almost entirely from the absence of this insect in the former case, and its presence in the latter; and the difference in the actual value of the crop is, of course, far greater.

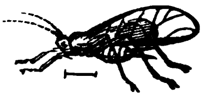

FIG. 416.—APHIS ROSÆ.

720. Section III. MONOMERA. The third section contains but one family, that of COCCIDÆ, sometimes called *Scale Insects*. These, although ordinarily of very small size, are amongst the most injurious to vegetation of the whole tribe. Like the last, they are remarkable for their powers of propagation; and when they once gain possession of a plant or young tree, its death is almost certain,—the minute size of the larvæ rendering it almost impossible to exterminate them. They furnish, however, some very important products. The bodies of many species are deeply coloured through their whole substance, and yield dyes of great value; the richness of which seems to depend upon the nature of the plant on which they feed. The *Coccus* of the ancients was a native of the Levant; but that which furnishes the *Cochineal* so highly valued at the present time, was originally confined to Mexico, where it feeds on the plants of the *Cactus*

tribe; it has been introduced, however, along with its proper food, into Spain and Algiers, as well as into the hothouses of this country. About 800,000 lbs. weight of Cochineal are annually brought to Europe; each pound of which contains about 70,000 insects. The *Lac* of the East Indies, which is extensively employed in the composition of varnishes, the making of sealing-wax, &c., is the product of another species of Coccus. The species which inhabit our own country, are important rather on account of the damage they commit, than the benefit they afford to Man. The bark of many of our trees often appears warty, by reason of a great number of small oval or rounded bodies, like a shield or scale, which are fixed to them, and in which no external traces of the insect are to be observed. These, however, are larvæ belonging to the tribe in question. Some of them are females; others young males, which are similar to them in form. At a subsequent period, they all undergo singular transformations. The males fix themselves to the plant, and pass into the pupa state, in which they remain completely at rest; and at last emerge as winged insects,—coming out of their cocoons backwards, with the wings extended flatly over their heads. The females, on the other hand, remain attached to the plant, and increase in size, in consequence of the development of a large number of eggs in their interior; but they undergo scarcely any other change. The eggs are deposited between the lower side of the body, and the surface to which it is attached; the latter having been previously covered with a sort of cottony secretion. The parent then dies, and her body dries up and becomes a solid cocoon, which covers the eggs. Here the eggs are hatched; and the young larvæ, which are at first active in their habits, quit their envelope, and ascend to the extremities of the branches; there they affix themselves by their sucking-beak, gradually increase in size, and lose their activity. In this condition they pass the whole winter; and it is not until the succeeding spring, that the characters of the sexes, which are henceforth to be so distinct, begin to show themselves.

ORDER VII.—HETEROPTERA.

721. **THESE** Insects bear a close general resemblance to those of the last Order; but are distinguished by the characters of the anterior pair of wings, which are tough at their bases and membranous only towards their points, and which fold nearly horizontally, partly overlapping each other. The mouth is formed nearly on the same plan as that of the Homoptera; being adapted solely for suction. By far the greater number of the Insects of this Order feed, like the preceding, upon the juices of plants; but some of them prey upon other and weaker Insects; and a few species (of which the numbers, however, sometimes multiply to a great extent) suck the juices of larger animals. The majority of this Order are found in tropical climates; and the species that inhabit those regions, are mostly ornamented with a great variety of beautiful colours and markings, which often vie with those of the most splendid of the Beetle tribes. Many species, however, are of aquatic habits; and these are all of an obscure or black colour. Nearly all the terrestrial species have the power of emitting, when they are suddenly alarmed or touched, a powerful odour; which is of a pleasing character in some species, but which in others (as the common Bed-bug) is very disgusting. Many of them seem to eject a poisonous fluid into the wound which they make for the purpose of suction. In some species, the wings are altogether undeveloped; or the upper pair is wanting. The insects of this Order continue active, and require food, during all the stages of their existence. They may be divided into two sections, distinguished by their residence, and by the modifications of their structure in accordance

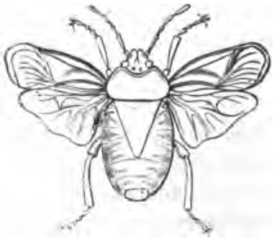

FIG. 417.—PENTATOMA.

with it;—the GEOCORISÆ, or *Land-Bugs;*—and the HYDROCORISÆ, or *Water-Bugs.*

722. Section I. GEOCORISÆ. This section contains a large number of families; nearly all of which, however, bear a strong general resemblance to that which includes the common Bugs,—the CIMICIDÆ. Some of the tropical species attain considerable size, being described as of the bulk of a Cockchafer; and they are much dreaded by the inhabitants of the regions they infest. Many of the Geocorisæ, however, are vegetable-feeders; and it is among these, that the most brilliant colours are exhibited.

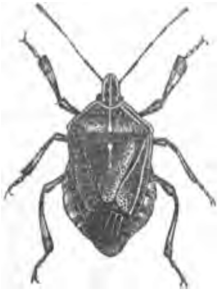

FIG. 418.—HALYS.

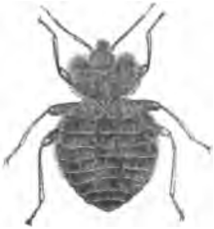

FIG. 419.—CIMEX LECTULARIUS.

The common *Cimex lectularius*, or Bed-bug, and its allies, never possess wings.—There is a curious group of very long-legged insects, which, though placed in this section, leads to the next; this is the family HYDROMETRIDÆ, some species of which may be met with on almost every pond or stream, skimming along the surface, and turning rapidly about, with the greatest ease and velocity. The form of the body strongly resembles that of a London wherry; the hind feet conjointly act as a rudder; and the motion is given by the two middle feet, which do not, however, dip into the water, but merely brush along its surface. The body is clothed on the under side with a fine coating of hairs, forming a sort of plush; which is evidently serviceable in preventing it from coming in contact with the water.

723. Section II. Of the HYDROCORISÆ, or true *Water-*

Bugs, there are two families only. The **Notonectidæ**, or *Boat-flies*, live almost entirely in the water, where they feed upon other aquatic insects; these they seize by means of their fore-legs. The legs of the hinder pair have a fringe of bristles along their edge; by which the surface, with which they strike the water in swimming, is greatly increased. Their general form is extremely well adapted for rapid progression in water; and it is from the peculiar aspect and movement of the body, that they have received the name of *boat-flies* or *water-boatmen*. The insects of this family swim on their backs; and the arrangement of all their organs has reference to this position. When stationary at the surface of the water, as is much their custom in calm hot weather, they very quickly obtain intelligence of the approach of danger, by means of their eyes, which are so placed that they are able to see both above and below the surface; and then, by a single stroke of their paddles, which are commonly stretched out at full length, they descend out of sight. Their motions are very quick in the element they are chiefly formed to inhabit; whilst on land they are scarcely able to walk. They can fly well; but they rarely exercise this power. The larva and pupa only differ from the imago in their smaller size, and in the deficiency of wings. When they descend into the water, the Notonectidæ carry down a supply of air for respiration, in a hollow which exists beneath the wings, when these are folded together.—The **Nepidæ**, or *Water-Scorpions*, receive their name from the scorpion-like form of their fore-legs, which are efficient instruments for seizing their prey. They are in most respects similar in structure and habits to the insects of the preceding family; but their motions are much slower, their legs not being so advantageously formed for swimming. The species represented in the accompanying figure is a very common inhabitant of our ponds.

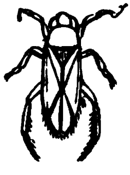
Fig. 420. — Notonecta.

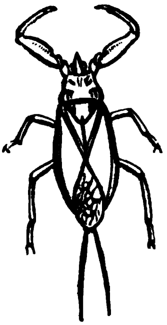
Fig. 421. — Nepa cinerea.

ORDER VIII.—DIPTERA.

724. THE *two-winged* insects constitute one of the most extensive Orders in the whole Class, not only in regard to the number of distinct species, but also from the occasional excessive multiplication of individuals of the same species. Many of them, also, have been constant attendants upon Man in all ages. They do not attract attention, however, from their size, for there are few that exceed an inch in length; nor is it on account of their beauty, for the majority of them are of dull colours; their forms, too, are rarely elegant; and of the habits and metamorphoses of a large proportion of them, very little is known. They owe the notice they have attracted, chiefly to the habits of certain species; which affect Man and the Domestic Animals, in various ways, both in their perfect and early states. However annoying these may be, it must not be forgotten, that other Diptera are of extreme service, in cleansing the surface of the earth of vegetable and animal impurities; and the carcass that is full of maggots would be much more prejudicial in its decomposition, than it is when principally eaten up by these voracious creatures. The mouth in the insects of this order is formed for suction, as already described (§ 616); but there are considerable varieties in the mode in which this is accomplished. Behind the wings are found a pair of moveable slender bodies, termed *halteres*, or balancers; these are probably the representatives of the second pair of wings. They are kept in continual motion, and are usually present even when the true wings are not developed. The Diptera all undergo a complete metamorphosis, as far as respects the comparative structure of the Larva and the perfect Insect; the former being generally cylindrical footless grubs, with no representatives of legs, except in a few species. But in many there is no proper transformation into the Pupa state; the skin of the larva not being thrown off, but hardening and contracting, so as to form a kind of cocoon. Within this, the body of

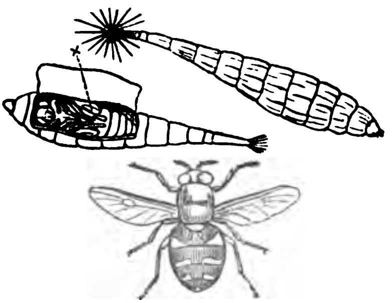

FIG. 422.—LARVA, PUPA, AND IMAGO OF STRATIOMYS CHAMÆLEON.

the larva is found, at first apparently but little altered, except that it has become detached from the skin, to the inside of which the organs peculiar to the larva, such as the parts of the mouth, remain adherent. Shortly afterwards, the inclosed being assumes the form of a soft and gelatinous mass, in which none of the parts of the future insect remain visible; some days afterwards, however, these organs become distinct, and the insect has then assumed the real state of pupa, though without having yet thrown off its larva skin. When ready to escape, it scales off the anterior end of its case, like a cap. Many larvæ, however, do throw off their skins when assuming the perfect state, and some form a regular cocoon. The duration of life in the perfect state is usually very short.

725. In subdividing this Order, we first separate from it a small but remarkable group, which forms the transition to the more aberrant orders of the class, especially the Aphaniptera. Some of them are entirely destitute of wings; and yet in their general structure they correspond with the Diptera. They are distinguished from all other insects by their curious mode of reproduction. Not only are the eggs hatched within the body of the parent, but the Larvæ are retained there until they have been transformed into Pupæ, in which state they come forth to the world. Hence this section has received the name of PUPIPARA. It contains two families, all the species of which are parasitic. The HIPPOBOSCIDÆ, sometimes called *Forest Flies*, are of small size, covered with bristles, and frequently destitute of wings. They are known by the French under the name of Spider-Flies. They reside upon quadrupeds and birds, running with great agility, and often sideways, burying themselves

amongst the hair or feathers. That which is parasitic on Sheep is known as the *Tick*. One minute species infests the Hive-Bee; and this is remarkable, not only for being destitute of wings, but of eyes also. In the other family, that of NYCTERIBIIDÆ, the general form still more nearly approaches that of Spiders. The group contains but a small number of species, all of which are parasitic upon Bats, and are termed Bat-Lice.

726. The remaining Diptera, constituting by far the larger proportion of the class, may be subdivided into four sections. In the first, NEMOCERA, the antennæ are composed of six joints; whilst in all the remainder, the antennæ are short, not having more than three distinct joints. In the second, NOTACANTHA, the last division of the antennæ is really composed of two; the proboscis does not project much from the mouth, and is furnished with only two lancets. In the third, TANYSTOMA, the antennæ have really only three joints, the last being usually terminated by a seta or bristle. And in the fourth, ATHERICERA, the antennæ are only two- or three-jointed, and the proboscis is capable of being withdrawn into the mouth.

727. Section I. NEMOCERA. To this division belong the two families of CULICIDÆ and TIPULIDÆ; the former known as the Gnat tribe, the latter as the *Harry Long-legs*. Both are remarkable for their beautifully-tufted antennæ; but the former are distinguished by the length of the proboscis. Gnats are well known to abound chiefly in damp situations; the reason being, that their larvæ are inhabitants of the water. In this state they are very active, swimming with great agility, and often descending; but coming to the surface to breathe, which

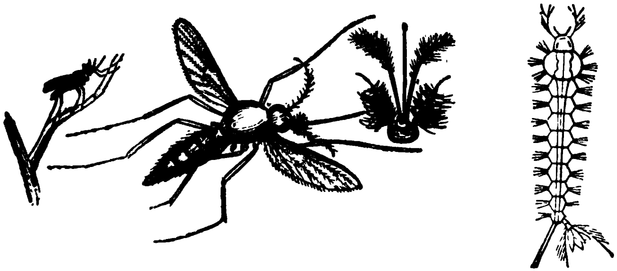

FIG. 423.—CULEX PIPIENS, female, natural size and magnified, with head of male.

they do head downwards, the respiratory orifice being at the end of a very prolonged spiracle arising from the end of the abdomen. When the final transformation occurs, the skin of the pupa, which is being cast off, serves as a kind of raft, which prevents the perfect insect from being immersed in water, and thus wetting its wings. The *Mosquitoes*, which infest many countries, especially in warm latitudes, or during the brief but hot summers of some colder ones, differ but little from the common Gnats. They sometimes appear in such swarms, especially in marshy districts, that they can be only kept off by fire. Their rapid multiplication is easily understood, when it is known that their whole series of metamorphoses only occupies three or four weeks in summer, so that there may be several generations produced in the course of one season; and that each female lays several hundred eggs.—The TIPULIDÆ also have feathered antennæ, but their proboscis is very short. Some of them very strongly resemble Gnats, both in the larva and perfect states; such are the *Midges*, of which one species is represented in Fig. 424. In another group, there is a strong resemblance to the Cynipidæ, or Gall-flies; both in their minute size, veinless wings, and mode of life. Their larvæ are terrestrial, and are very commonly developed within a sort of *gall*, produced by the puncture made by the parent in the tissues of plants, when depositing its eggs. Some species make their puncture in the young sprigs, others in the leaves, and others in the flowers; and there are several which are extremely injurious both to the Gardener and the Agriculturist. Thus the Wheat crops of this country are often seriously injured by the *Cecidomyia Tritici;* the eggs of which are deposited by the female in the centre of the corolla, where the larvæ are hatched; and it is probably by devouring the pollen, that they are most injurious to the plant. Another species,

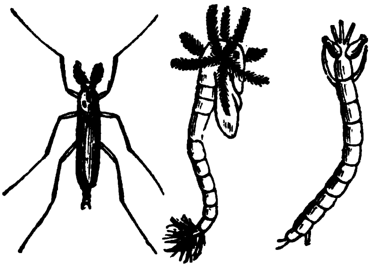

FIG. 424.—CHIRONOMUS, with its Pupa and Larva, magnified.

C. destructor, is known in America under the name of the Hessian Fly; this attacks the lower part of the stem of the wheat. The proper *Tipulæ*, or *Harry Long-legs*, are the largest species of the family. Their larvæ generally live in the earth, in the rotten parts of trees, &c., and many of them do great mischief by feeding upon the roots of grass and corn.

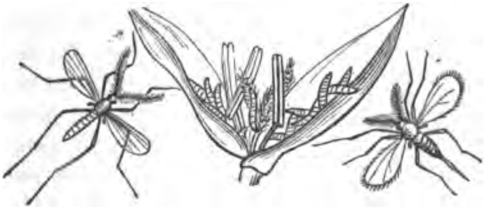

FIG. 425.—CECIDOMYIA DESTRUCTOR, and C. TRITICI, with the Larvæ of the latter feeding in wheat flowers, magnified.

728. Section II. NOTACANTHA. The second Section of the Diptera contains three families, STRATIOMIDÆ, BERIDÆ, and CŒNOMYIDÆ, which do not attract much attention, although some of the species contained in them are very abundant. They are mostly small but gaily-coloured insects; and are most numerous in moist situations, in which the larvæ are generally produced. Some of the larvæ, as that of *Stratiomys Chamæleon* (Fig. 422), are completely aquatic; and respire, like the larvæ of the Gnats, by extending their tails to the surface, the spiracle or breathing-pore being in that situation. They mostly feed upon vegetable, rather than upon animal, juices.

729. Section III. TANYSTOMA. The insects composing the third section have usually a more perfect mouth, than those of the other divisions; and they are also remarkable for the structure of the head of the larvæ, which possess two claw-like appendages, by which they attach themselves to the substances that afford them support. Many of the perfect insects are eminently carnivorous or insectivorous; as are also some of the larvæ. There is a genuine metamorphosis in this group; the larva-skin being cast off at the entrance of the animals into the pupa-state. In this state they much resemble the perfect insect; the limbs being inclosed in distinct sheaths, and folded on the breast.

The perfect Insect escapes from the pupa-state by means of a slit along the back. To this group belongs the family **Tabanidæ**, or *Gad-fly tribe;* which comprises some of the largest Dipterous insects, and which is pre-eminently distinguished for the tormenting powers which different species possess. They pierce the skins and suck the blood of various Quadrupeds, both wild and domesticated; and do not spare Man himself. They chiefly abound in woods and pastures; and the buzzing noise which they make, has obtained for them the designation of "the breeze." The insect of which Bruce has spoken, in his Travels in Africa, under the name of *Zimb,* is probably a species of this family. He describes it as attacking cattle in so dreadful a manner, that, unless immediately driven to the sands, they forsake their food, and run wildly about the plains, dreading even its very sound, until they die, worn out with fatigue, fright, and hunger. The Camel, and even the thick-skinned Elephant and Rhinoceros, are said to be subject to this enemy.

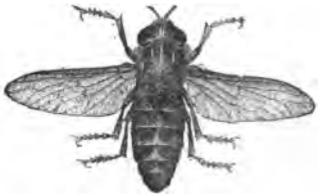

Fig. 426.—Tabanus Bovinus.

730. The family **Bombyliidæ** are distinguished by their very long proboscis, with which they suck the nectar from flowers. They fly with great rapidity, and hover over flowers without settling; making at the same time a loud buzzing noise with their wings. Some of them have a remarkably Bee-like form. The family **Anthracidæ**, which is nearly related to the preceding, is chiefly composed of exotic species, which are generally large or of moderate size, often covered with hair, and beautifully coloured. They fly in the sunshine with great agility; and subsist, like

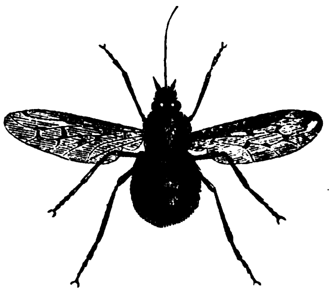

Fig. 427.—Bombylius.

the preceding, upon the juices of flowers. In general the proboscis is comparatively short; but in a few instances, as in the *Nemestrina longirostris*, it is of extraordinary length (Fig. 321). This section also contains several other families of less interest and importance; among them we may mention the ASILIDÆ, which live by rapine, seizing Flies, Tipulæ, Humble-Bees, and even Wasps, and sucking their juices.

731. Section IV. ATHERICERA. The Dipterous insects of the fourth tribe are principally vegetable-feeders in their perfect state, only a few being carnivorous or insectivorous; but their larvæ are generally extremely voracious, and will devour almost any kind of soft animal matter. This section includes the *Flies* strictly so called, the *Bot-flies*, and many other tribes.—The first family, that of SYRPHIDÆ, bears an extremely close resemblance to the Humble-Bees and Wasps, in the nests of which some species among them deposit their eggs; this resemblance is evident in the accompanying figure, which represents the *Eristalis*, or Drone-fly (A), and the *Anthophora retusa*, or Spring Wild-Bee (B), two insects which differ entirely in their habits,—the former being the very personification of luxurious idleness, doing nothing but sip the nectar from the brightest flowers and bask in the sunshine on the leaves,—whilst the latter toils all day long, either in the construction of the nest, or in provisioning it with pollen paste. The wisdom of the Creator has provided the insects of the former group, as a check upon the too great increase of the latter; for the larvæ of the Syrphidæ, when hatched in the nests of the Bees, destroy *their* larvæ, and live at their expense. Some species restrain, in a similar manner, the excessive multiplication of the Aphides. The perfect insects feed almost solely upon flowers, preferring those of the Compositæ; and they delight to hover immoveably over certain spots, to which they will return,

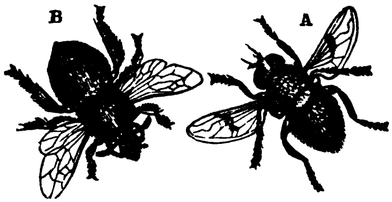

FIG. 428.—DRONE-FLY AND SPRING WILD-BEE.

if disturbed, a considerable number of times. Above a hundred species inhabit Britain. In a few of them the larvæ are aquatic, and the posterior part of the body is prolonged into a respiratory tube, whence they have received the name of "rat-tailed" larvæ.

732. The form and habits of the family Muscidæ, or *Fly tribe*, are generally known. The family is an extremely numerous one, above 1700 species having been recorded as existing in Europe, of which about half are natives of this country; and there are probably at least as many more, which have not been described. The strong general resemblance which exists among all the species, together with their small size, makes it difficult to discriminate them readily. The larvæ of these insects, commonly known as *maggots*, are soft, worm-like, footless grubs, possessing on the head a couple of retractile hooks, by which they can cling to the substances on which they feed. They devour various substances, both animal and vegetable, living, recently dead, or far advanced in putrefaction. The eggs are deposited by the female (as in other instances) in the neighbourhood, or in the very substance, of the food which is adapted for the support of the larva, however little this may be to its own liking. Some of these larvæ are remarkable for their leaping powers,—whence they are commonly termed "hoppers." This is especially the case with the larva of the *Piophila casea*, or Cheese-hopper; whose mode of springing into the air is very curious. When preparing to leap, it first raises itself on its tail; in which position it is enabled to balance itself, by means of some prominent tubercles on the last segment of the body. It then bends itself into a circle; and having brought the head towards the tail, it stretches out the two hooks of the mouth, fixing them into two cavities at the other extremity of the body.

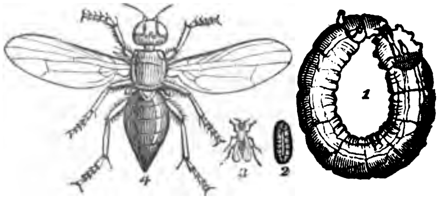

Fig. 429.—1. The Cheese-hopper preparing to spring.—2. Natural size of the Larva.—3, 4. The Fly to which it is transformed: natural size and magnified.

It then contracts the body from a circular to an oblong figure; the contraction extending in a manner to every part of the body. It now suddenly lets go its hold, and straightens the body, with such violence, that the noise produced by its hooks is very perceptible. The height of the leap is often from twenty to thirty times the length of the body; exhibiting an energy of motion, which is particularly remarkable in the soft Larva of an Insect. A Viper, if endowed with similar powers, would throw itself nearly a hundred feet from the ground. The learned Swammerdam, who devoted much attention to the anatomy and habits of this creature, observes—"Now let the sharpest geniuses, and men of the greatest penetration and learning, judge if a creature, on the fabric of which there plainly appears so much art, order, contrivance, and wisdom, nay, in which is seen the hand itself of the Omniscient God, could possibly be the production of chance or rottenness." This observation refers to the idea formerly entertained almost universally, that the Maggots, which make their appearance in the midst of decomposing matter, are the results or products of that decomposition. Experiments devised for the purpose, however, have clearly shown, that there is here no exception to the general rule; for that, if the parent Insects be carefully excluded, no maggots will make their appearance in a decomposing mass of any description.—Of the voracity of the larvæ, and the rapidity with which they undergo their transformations and propagate their kind, some idea may be formed from the estimate of Linnæus,—that three Flesh-flies and their progeny would devour the carcass of a dead Horse more speedily than a Lion would do. If this estimate is at all exaggerated, it is probably not much so. Hence we see the vast importance of these Insects in the economy of Nature; for they are called into existence just in proportion to the demand for them,—the eggs of the parent not being developed, unless they are deposited in a fit situation, so that the number of individuals will not be increased unless there is matter for them to feed on,—whilst, on the other hand, the rapidity of the growth and metamorphoses of these Insects is greatly increased, by the warmth that promotes the decomposition of the substances, which they are destined to remove.

733. The **Œstridæ**, or *Bot-flies*, are a family very remarkable in regard to their structure and habits. The perfect insects resemble large Meat-flies in form, are very hairy, and have these hairs coloured in rings, like Humble Bees; but they are seldom seen, the duration of their lives being very short in this condition. Their chief peculiarity consists in the absence of any proper mouth in the Imago (in which respect there is an analogy with the Strepsiptera, § 714), and in the peculiar habitation of the Larva. This is always found in living animals,—its situation, however, varying with the species; and almost every herbivorous animal having one or more peculiar to it. The egg is, in some cases, deposited by the parent in situations where the larva may burrow into the flesh; there it occasions inflammatory tumors, the fluids contained in which afford it nourishment. These have an evident analogy, therefore, to the Cynipidæ, which produce Vegetable galls. In other instances, the eggs or larvæ, existing upon spots which the animal is in the habit of licking, are conveyed by the tongue into the mouth, whence they pass into the stomach. There they remain until full-grown; and then they quit the body (as do also those which inhabit the flesh), and fall to the ground, beneath the surface of which they undergo their transformations. The larvæ of one species, which inhabits the Sheep, are found in the frontal sinuses of the skull. Man is subject to the attacks of one or more species; which do not, however, inhabit this country.

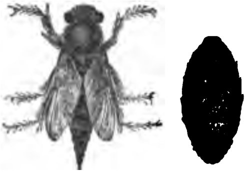

FIG. 430.—ŒSTRUS AND LARVA.

Division II.—APTEROUS INSECTS.

734. Besides the foregoing Orders, we must include three others in the Class of Insects, on account of their correspondence with it in general structure; although they present only one, or even neither, of the two characters which have been stated to be its peculiar distinctions,—namely, the presence of wings in the perfect state,—and the metamorphosis.

Order IX.—APHANIPTERA.

735. Of the three Apterous orders, this one undoubtedly approaches nearest to the true Insects; for we find in it a metamorphosis, and even rudiments of wings; whilst the structure of the mouth most nearly approaches that of the Diptera. The *Fleas* and their allies, which constitute this order, resemble the Diptera also in their suctorial habits; and feed exclusively upon animal juices. Their larvæ come forth from the egg in the state of minute worms, possessing considerable activity, and feeding upon animal matter, in the midst of which the eggs were deposited by the parent. They afterwards enclose themselves in a small cocoon of silk, which is often covered with dust; and in this they undergo their change into the Pupa state. In the Imago, the rudiments of wings are visible, in the form of little scales, attached to the second and third segments of the body; there is, however, no proper distinction of thorax and abdomen.—The Common Flea

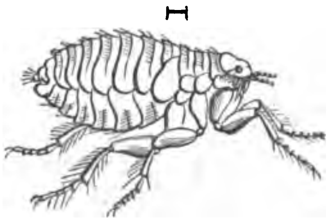

Fig. 431.—The Flea. (*Pulex irritans.*)

is known to every one. There is a very curious species, of more minute size, in the West Indies; which is commonly known under the name of *Chigoe* or *Jigger*. This burrows beneath the skin of the foot, and soon acquires the size of a pea, by the enormous growth of the abdomen when distended with eggs. If these eggs remain to be hatched beneath the skin, great irritation, and even very troublesome sores, are sure to result; and it is consequently necessary to extract the insect entire, with great care, as soon as the indication of its presence is given by a slight itching or tingling.

ORDER X.—ANOPLURA.

736. THE Insects of this Order,—the *Louse* and its allies,—are regarded with the greatest disgust by the common consent of civilized Man; because their presence on the body is usually an indication of a gross want of cleanliness of habit. Most of the lower animals, however, are infested with one or more species; from the attacks of which they are not able to defend themselves; and Man is subject to a peculiar disease, which seems much to favour their production. They undergo no metamorphosis; and their generations succeed each other very rapidly. They are destitute of the true compound eyes; but have one or two minute ocelli on each side of the head. The legs are short, and terminated by a strong nail, or by two opposing hooks; whereby these animals can easily fasten themselves to the hairs of quadrupeds, or the feathers of birds; of which animals they suck the blood, and upon the bodies of which they pass their lives; attaching their eggs, too, upon these cutaneous appendages.

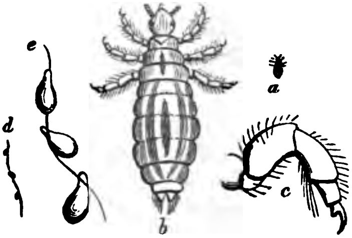

FIG. 432.—*a*, THE COMMON LOUSE; *b*, magnified; *c*, one of the legs magnified; *d*, eggs; *e*, ditto magnified.

The number of species is very considerable; for it would appear that almost every quadruped and bird has a kind almost peculiar to itself,—the same Louse not being found upon different animals, except upon such as have analogous characters and habits; whilst one animal frequently supports two or more species of these parasites.

ORDER XI.—THYSANOURA.

737. IN the Insects of this Order,—which resembles the preceding in neither having wings, nor undergoing metamorphosis,—there is a remarkable diversity of structure, especially in regard to the mouth. Some of them possess as complex a buccal apparatus as the Mandibulate Insects; whilst in others there is scarcely a perceptible opening. The same is the case with regard to the eyes; these organs being fully developed in some, and almost rudimentary in others. — The Order contains two families. In the first, the LEPISMIDÆ, the abdomen is furnished on each side with a row of moveable appendages, like false legs; and is terminated by long pointed bristles, of which three are usually most remarkable.— The *Machilis* has long antennæ, consisting of a great number of joints; its palpi also are very large; and its eyes are composed of numerous facets, and occupy nearly the whole head. It frequents stony places, and leaps well with the aid of the appendages to the tail. The *Lepisma*,—of which one species is known under the name of the *Sugar Louse*, from its aspect and habits,—has the eyes very small, composed of few facets, and wide apart; its body is flat, and is terminated by three threads of equal length, not fitted to assist in leaping.

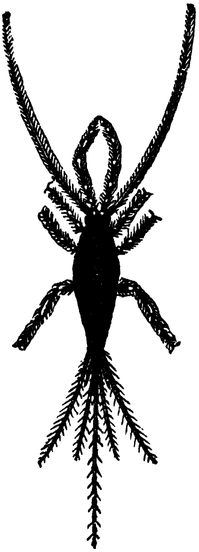

FIG. 433.—MACHILIS.

—In the Poduridæ, the appendages to the sides of the abdomen are wanting; but the extremity of it is prolonged into a forked tail, by which these insects can execute very surprising leaps. This, when not in action, is bent forwards beneath the abdomen; and it is by the sudden extension of it, that the leap is produced. From this conformation, the *Poduras* are commonly known under the name of *Spring-tails.* The scales with which their bodies are covered, are objects of great interest to the Microscopist; for they have a most elaborate and minute structure, which can only be made out by instruments of the best quality; hence they are very valuable *test objects.*

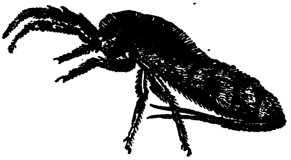
Fig. 434.—Podura.

CHAPTER IX.

OF THE CLASS OF ARACHNIDA.

738. This class is composed of Articulated animals, which have a great analogy with Insects, and which are equally fitted to live in the air; but which are distinguished from them at the first glance, by the general form of the body, and by the number of limbs; and which differ also from those animals, in several important particulars of their internal structure. All the Arachnida have the head united with the thorax, and are destitute of antennæ; they have *four* pairs of legs and no wings; most of them breathe by means of air-sacs, instead of by prolonged tracheæ; and nearly all of them have a complete circulating apparatus.

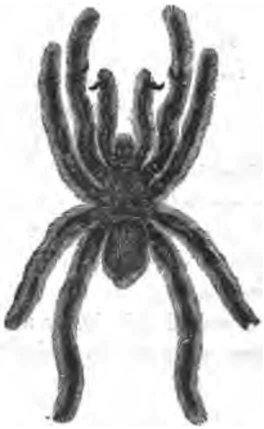

FIG. 435.—MYGALE.

739. The tegumentary skeleton of Arachnida is generally less firm than that of Insects; and their body is composed of two principal parts, nearly always distinct:—one called the *cephalo-thorax*, because it is formed by the head and the thorax united into a single mass;—the other termed the *abdomen*, and composed sometimes of a series of distinct rings (such as we see in the Scorpions—Fig. 447), and sometimes of a soft globular mass, without any evident divisions (as is the case among the ordinary Spiders—Fig. 442).

740. The organs of locomotion are all fixed to the cephalo-thorax, and consist of eight legs, very similar to those of Insects, and nearly always terminated by two hooks. In general their

length is considerable and they easily break; but, as amongst the Crustacea, the stump, after being healed, produces a new limb; which grows by degrees, and becomes similar to the one of which the animal had been deprived. The Arachnida never present any vestige of wings: and their abdomen is always entirely destitute of locomotive appendages.

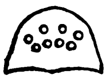

FIG. 436.

741. Upon the anterior portion of the cephalo-thorax, we find the mouth and eyes. These last organs are always simple, and of considerable number. We may generally count eight, and in each of them may be distinguished a transparent cornea, behind which is found a crystalline lens, and a vitreous humour; then a retina formed by the termination of an optic nerve, and an envelope of colouring matter.—Nothing is known regarding the instruments by which the sense of hearing operates in the Arachnida; but there are numerous proofs of the existence of such a faculty amongst these animals; and it would even appear that certain of them are sensible to the charms of Music.—The sense of touch is exercised principally at the extremities of the legs, and by the appendages with which the mouth is furnished.

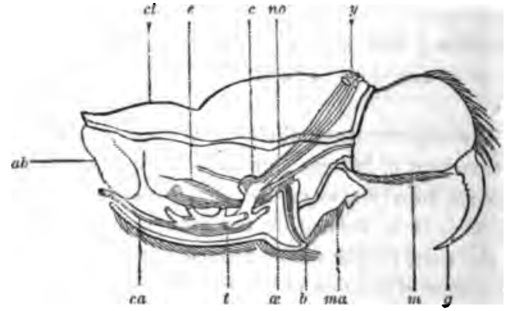

FIG. 437.—SECTION OF THE CEPHALO-THORAX OF A MYGALE, showing the arrangement of the nervous sytem: *ct*, cephalothorax; *m*, mandible; *g*, moveable hook which terminates it; *b*, mouth; *æ*, œsophagus; *e*, stomach; *ab*, origin of abdomen; *c*, cephalic ganglion; *t*, ganglionic mass of the thorax; *ca*, cords which unite it to the abdominal ganglia; *no*, optic nerve; *y*, eyes.

742. The nervous system of the Arachnida presents very great differences; sometimes (amongst the Scorpions for ex-

ample) it is composed of a series of eight ganglionic masses, united together by double cords of communication, and forming a chain extended from one end of the body to the other, in nearly a uniform manner; in other instances (as amongst the Spiders, &c.) we find all the ganglia of the thorax united into a single mass (*t*, Figs. 437 and 439), whence two cords proceed backwards, which go to a single abdominal ganglion. In other respects, the general arrangement of these parts is always the same. The anterior ganglia, situated before or above the œsophagus, and most commonly considered as representing the brain of these animals, give origin to the optic nerve in front, and are continuous behind with the collar of nerves surrounding the œsophagus; the other ganglia are situated below the alimentary tube, and send nerves to the limbs, to the appendages of the abdomen, &c.

743. The Arachnida are carnivorous, but in general confine themselves to sucking the juices contained in the bodies of their victims; and in order to enable them more easily to effect the capture of animals of whose strength they would be afraid, Nature has endowed many of them with a poisonous apparatus. The greater part are supported on Insects, which they seize whilst alive; some of them, however, live as parasites. Among the first, the mouth is supplied with a pair of mandibles, furnished with moveable hooks, or formed like a pair of pincers,—with a pair of thin or lamellated maxillæ, each bearing a large feeler more or less resembling a leg,—and with a lower lip. Amongst the parasitical Arachnida, the mouth has the form of a small trunk, from which there issues a kind of lancet formed by the maxillæ.

744. The moveable hook of the mandibles has a small opening near its extremity, which is the orifice of the excretory canal of the poison-gland already mentioned; and the liquid, which it pours into the bottom of the wounds made with the mandibles, almost immediately causes the destruction of the animal attacked; but it is too weak to injure Man.

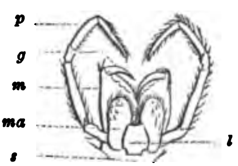

FIG. 438.—BUCCAL APPARATUS OF A SPIDER: *s*, sternum; *l*, labrum; *ma*, maxillæ; *p*, maxillary palpi; *m*, mandibles; *g*, hook terminating the mandibles.

745. Certain of the Arachnida are provided with another poison apparatus, destined for the same use, and serving equally as a weapon of defence: such is the hook by which the abdomen of Scorpions is terminated (Fig. 449). This sting has beneath its point several openings, which communicate with a poison-gland; and the sting of these Arachnida often proves mortal, even to animals as large as Dogs. The large Scorpions of warm countries are fatal even to Man, but the sting of the species which inhabit Europe never appears to be mortal; there usually results from it a local inflammation more or less violent, accompanied by fever and depression, and sometimes by vomiting, pains in the whole body, and trembling. To overcome these attacks, physicians advise the use of ammonia (or spirit of hartshorn), administered internally as well as externally; and the application of emollient substances to the wound.

746. The intestinal canal is generally very simple; but has sometimes cæcal appendages, which penetrate even into the interior of the limbs. In general, tubes analogous to the biliary vessels of insects open into the intestine near the anus; but amongst some of the Arachnida, such as the Scorpions, there exists a liver composed of four glandular clusters. It is also in

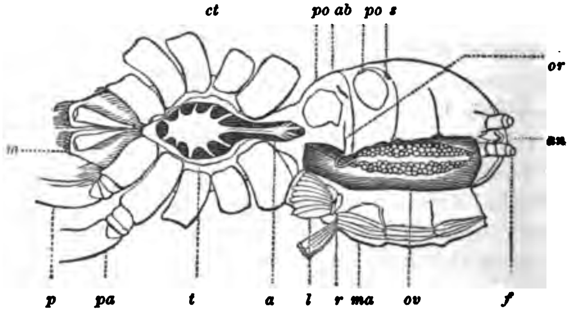

FIG. 439.—ANATOMY OF MYGALE: *ct*, cephalothorax opened below, and giving attachment to the limbs, whose first joints are exhibited; *pa*, legs of the 1st pair; *p*, palpi; *m*, mandibles; *ab*, abdomen; *t*, thoracic nervous mass; *a*, abdominal ganglia; *po*, respiratory sacs; *s*, stigmata; *l*, leaf-like folds in the interior of one of these laid open; *ov*, ovaria; *or*, orifice of oviducts; *ma*, muscles of the abdomen; *an*, anus; *f*, spinnerets.

the neighbourhood of the anal opening, that we find the secreting glands of the silky matter; and also the spinnerets, by whose aid several of the Arachnida weave for themselves webs, which are often very extensive and of extreme delicacy.

747. The respiration of the Arachnida is aërial, like that of Insects, and is sometimes effected by means of tracheæ; but among the greater part of these animals, and especially amongst the Spiders and Scorpions, it is concentrated in certain vesicles lodged in the abdomen, and called pulmonary sacs. These last organs have in their interior a multitude of membranous plates, arranged like the leaves of a book: and they thus bear a stronger resemblance to internal gills, than to true lungs. Each sac receives the air by an opening situated on the lower side of the abdomen; and there are sometimes two, sometimes four, or even eight of these stigmata. Certain Arachnida possess at the same time both pulmonary sacs and tracheæ; the *Segestriæ* are thus formed. Others, such as the *Pseudo-Scorpions* and *Mites*, are provided with tracheæ only. These tubes have the same structure as in Insects; and the air penetrates to them by two very small stigmata, situated on the lower side of the abdomen.

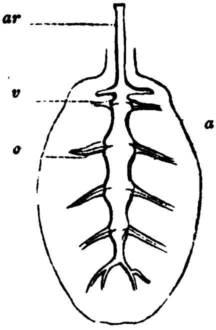

Fig. 440.—Heart of a Spider: *a*, border of the abdomen; *c*, heart; *ar*, large artery, proceeding from its anterior extremity; *v*, pulmonary vessels.

748. The blood is white among all the animals of this class. The pulmonary Arachnida are furnished with a complete circulating apparatus. The heart, situated on the back, has the form of a long vessel, and gives origin to different arteries; the blood after having traversed the body is returned to the pulmonary sacs, and arrives at the heart after following a course similar to that which it traverses in the Crustacea (Anim. Physiol. § 292). Amongst the Arachnida whose respiration is effected only by the aid of tracheæ, the apparatus for circulation is but little developed; there appears to be only a simple dorsal vessel, without arteries or veins.

749. The Arachnida lay eggs like Insects; and the male differs in general from the female in the form of its maxillary

palpi, whose use appears to be very important; a great number of these animals envelop their eggs in a cocoon of silk; and sometimes the mother remains with her young family to protect it, and even carries the young ones on her back when they are too weak to walk. All these animals undergo several changes before they arrive at adult age; and certain of them experience a species of metamorphosis, for there are some, whose limbs consist at first of only three pair, and which acquire a fourth at a period more or less advanced.

750. The Arachnida are endowed with varied instincts, which are sometimes not less remarkable than those of Insects; and we are perhaps even to attribute to them higher faculties; for some animals of this class are capable of undergoing a kind of education, and give evidences of a certain degree of Intelligence. Several of them use particular stratagems to carry off their prey; and others display singular industry in the construction of their habitations. We have elsewhere had occasion to speak of the remarkable nest of the *Mygale* (ANIM. PHYSIOL. § 700); and the webs which our garden Spiders spread with such admirable regularity, are equally curious. The silk with which these animals thus construct retreats for themselves, spread snares for their prey, and form cocoons for their eggs, is secreted by an apparatus situated in the posterior part of the abdomen. This apparatus consists of several bundles of vessels, twisted together, and terminating in minute apertures, which are pierced at the summit of four or six conical or cylindrical projections, called *spinnerets*, and situated at the end of the tail. The gluey matter thrown out through these pores, acquires consistency by its contact with the air, and consists of threads of an extreme fineness, and a length not less remarkable; by the help of its feet, the animal collects a number of these threads into a single cord; and each time that, in balancing itself, the spinnerets touch the body upon which it rests, it there

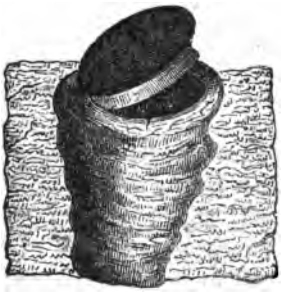

FIG. 441.—NEST OF MYGALE.

fastens the end of one of these threads, of which the opposite extremity is still inclosed in the secreting apparatus, and of which it can consequently increase the length at pleasure. The colour and thickness of these threads vary greatly; a Mexican Spider forms a web composed of red, yellow, and black threads interwoven with astonishing skill; and it has been calculated that ten thousand threads from the pores of a single spinneret of some of our common Spiders do not equal in thickness one of our own hairs; whilst among other species inhabiting warmer climates, they form such strong webs, that they are sufficient to stop small birds, and even Man has to use some effort to break them. The manner in which Spiders employ their skill in working, is subject to no less variation; some of them are satisfied with spreading their threads irregularly; others weave a web, whose meshes are of extreme regularity. Sometimes we see them motionless in the middle of their web, watching for their prey; at other times they conceal themselves in a retreat, which they construct very near, and which has in some instances the form of a silky tube, in others that of a small cup.

751. The Arachnida are divided into two orders, according to the structure of the organs of respiration and circulation.

I. The *Pulmonary* Arachnida; which are principally characterised by the existence of pulmonary cavities, and by a vascular apparatus; but we may also recognise them by other peculiarities of structure; thus the number of their eyes is six, eight, or even still greater, and we also find two, four, or eight stigmata on the under part of the abdomen. The general form of these animals varies; some, as the Spiders, have a globular body, with spinnerets at its extremity, and the palpi small;—whilst in other instances, as the Scorpions, the body is lengthened, and composed of several rings, the palpi large, extended like arms, and armed with pincers; and the abdomen is not terminated by spinnerets, but usually by the poisonous apparatus.

II. The *Tracheary* Arachnida; which have no pulmonary sacs, but breathe by tracheæ like Insects, and appear to have no complete vascular apparatus for the circulation of the blood. Some of them have no eyes; and amongst those which possess these organs, we never find more than two or four. Some of these animals, known under the name of *False-Scorpions*, very much resemble Spiders, and are remarkable for the length of their limbs; others have the mouth formed for sucking, and constitute the family of *Acaridæ*, or Mites.

ORDER I.—PULMONARIA.

752. By the characters just now stated, this order may be divided into two sections;—the ARANEIDA, or *Spiders*, having small foot-like palpi, not terminating in pincers; and the PEDIPALPI, or *Scorpions* and their allies, having very large palpi, which terminate in pincers or large hooks.

753. Section I. ARANEIDA. The Arachnida of this group all agree, more or less closely, with the common Spider, in their form and structure. Their cephalothorax appears as if composed of but a single segment, and is covered with a sort of horny buckler, usually of oval form; the abdomen is appended to it by a very short footstalk, and usually consists of a soft and tumid mass. The eyes are nearly always eight in number; although there are sometimes but six. The mandibles terminate in a very sharp moveable hook, which is pierced near its extremity by a small aperture, serving as a passage for the poison secreted by a gland lodged in the preceding joint. The legs are inserted almost in a circular manner around the cephalothorax (Fig. 439); they are all of nearly the same form; and each of them is composed of seven joints, the last being armed with two hooks, which are commonly toothed like a comb. The pulmonary sacs in this order are only two in number, or may even be reduced to a single one; they are placed near the base of the abdomen, and their position is indicated externally by a brownish or whitish spot. All the members of this section are provided with spinnerets; but it is only in a comparatively small number, that we find the power of constructing silken webs of any great extent. The ARANEIDA are divided by M. Walcknäer, who has made this group his especial study, into families, according to the

arrangement of the mandibles and eyes, which corresponds very remarkably with their respective modes of life. These families, and their principal subdivisions, are as follows :—

I. Venantes, incessantly running or leaping about the vicinity of their abode, to chase and catch their prey.	Latebricolæ, hiding in holes and fissures. Tubicolæ, inclosing themselves in silken tubes. Cellulicolæ, sheltering themselves in small cells. Cursores, running swiftly to catch their prey. Saltatores, leaping and springing with agility to seize their prey.
II. Vagantes, wandering abroad, and incessantly looking out for prey. No fixed residence except at the period of oviposition.	Laterigradæ, walking and running sideways or backwards; occasionally throwing out threads to entrap their prey.
III. Errantes, prowling about the neighbourhood of their nests, or near the threads which they throw out to catch their prey.	Nitidelæ, going abroad, but making a web for their nests, whence issue threads to entrap their prey. Filitelæ, going abroad, but spreading long threads of silk about the places where they prowl, in order to entrap their prey.
IV. Sedentes, spinning large webs to entrap their prey, lying in wait in the middle or at the side.	Tapitelæ, spinning great webs of a close texture, and dwelling therein to catch their prey. Orbitelæ, spreading abroad webs of a regular and open texture, either circular or spiral, and remaining in the middle or on one side to catch their prey. Retitelæ, spinning webs of an open meshwork, and of an irregular form, and remaining in the middle or on one side to seize their prey.
V. Natantes, swimming in water, and there spreading their filaments to entrap their prey.	Aquitelæ, spreading filaments in the water to entrap their prey.

754. The first family, that of the Venantes, or *Hunting-Spiders,* may be naturally divided into two groups; the first being more sedentary, and the second more active. At the head of the first group stands the tribe of Latebricolæ, which consists of the genus *Mygale* (Fig. 435) and its allies; these are the largest of the whole family, some of them occupying, in a state of repose, a circular space of six or seven inches in diameter. They form their nests in the slits of trees, beneath the bark, in the cavities of stones and rocks, or on the surface of the leaves of various trees. Some of them burrow deeply into the ground, choosing dry shelving situations exposed to the sun, and con-

structing subterranean cylindrical galleries, often two feet deep, and so tortuous that it is difficult to follow them. These they line with a silken tube, forming at its entrance a moveable lid, composed of silk and earth, attached to the silken lining by a sort of hinge; and this is adapted, by its size, situation, and weight, to close the opening so precisely, as scarcely to allow its entrance to be distinguished from the neighbouring soil,—shutting of itself when the Spider enters its retreat or passes out of it. When an attempt is made to open it from without, the Mygale holds it down firmly with its hooked feet. The Mygale spins a sort of cocoon around its eggs, enclosing a hundred or more; they are hatched within it, and the young undergo their first changes before quitting it. The various species of this group are inhabitants of tropical and the warmer temperate climates; it is only in the former, that we find those of largest size.—The TUBICOLÆ and CELLULICOLÆ are not sufficiently distinct from the preceding, to require particular notice. They are mostly of smaller size, and inhabit temperate climates, where they may be considered as representing the Mining Spiders.

755. The tribes of CURSORES, or *Runners*, and SALTATORES, or *Leapers*, forming the second division of the Hunting-Spiders, are distinguished by the activity with which they pursue their prey. The former, which are sometimes called Wolf-Spiders, have the legs adapted for running, and live mostly upon the ground. Those of the genus *Lycosus* dwell in holes which they have formed, lining their inside with silk, and increasing their size as they grow. Some of them take up their abode in holes of walls, where they make silken tubes; the outside of which they cover with earth or sand, and in which they moult or hybernate, having first closed the entrance. The females also lay their eggs in these tubes; inclosing them in a silken cocoon, or egg-case, which they carry about with them when they go out to hunt. The young ones fasten themselves, as soon as they are hatched, upon the body of their parent; and there remain attached, until they are sufficiently strong to seek their own food. These Spiders are very voracious, and defend their habitations and young with great courage. A species of this genus,

the *Tarentula*,—so named from the city of Tarentum, in Italy, in the neighbourhood of which it is common,—is very celebrated on account of its reputed venomous powers. Like all the Spiders, it has a poison-gland in its mandibles; but the idea that its wounds are followed by death, or by a complaint termed Tarantism, which can only be cured by the aid of music and dancing, has originated in the imagination only.—Some species of the genus *Dolomedes* live upon the tops of trees, upon the leaves of which they make a funnel-shaped silken nest; whilst others inhabit plants in the neighbourhood of water, on which they find their prey,—running upon its surface with surprising quickness, and even entering it without being wetted.—The Spiders of the tribe of SALTATORES, or *Leapers*, have, as might be anticipated from their name, the legs fitted rather for leaping than for running. One of these is very common in summer upon walls and windows exposed to the sun; and its habits may be watched with much interest. It moves in short leaps, and stops suddenly at intervals, raising itself upon its legs, as if to survey the neighbourhood. When it discovers a fly, or especially a gnat, it approaches it cautiously until within leaping distance; when it darts upon it,—not fearing to take even a perpendicular leap, because it always at the same time suspends itself by a thread, which it winds off as it advances. This thread also serves to suspend it in the air, and enables it to mount up again to the spot from which it leaped, or to sustain it whilst the wind carries it from place to place. Many species of this group construct, amongst leaves, under stones, &c., silken nests, in the form of oval sacs, open at each end; into which they retire in order to take rest, to moult, and to take refuge against the inclemency of the weather. If menaced with danger, they quit these retreats, and run off very rapidly. Some species construct, with the same material, a kind of tent, which serves as the birthplace of their posterity, and in which the young reside for some time with their parent.

756. The family VAGANTES, or *Wandering Spiders*, consists of the single tribe LATERIGRADA; the name of which (meaning Side-Walkers) expresses the curious power which they possess,

of moving sideways. They conduct us towards the web-spinning Spiders, in using their silken threads, not only for the construction of habitations for themselves or of envelopes for their eggs, but also for the purpose of entrapping prey. The threads, however, are not arranged with any regularity, but are laid singly. These Spiders generally remain at rest, with the legs spread out, upon the leaves or stems of plants; running, however, with great rapidity, in pursuit of their prey, when it comes within their reach. Others, however, live in rocky places; and have the feet so formed, that they can adhere even to very smooth surfaces, in any position of their own bodies. They usually construct very elaborate cocoons for the protection of their eggs. Those which live among plants affix the cocoons to the leaves, and draw together their edges so as to conceal them. Those, on the other hand, which live upon rocks, usually conceal the cocoon within their own dwelling-place; which is an oval conical tent, something like a Limpet in form, attached at its base to the rock, but having an aperture at each end, furnished with a kind of valve through which the animals go in and out. The outer covering of this tent is composed of a sort of yellowish taffety, thin (like the skin of an onion), but resisting; whilst the inner covering is soft and pliant.

757. The Spiders of the family ERRANTES, or *Prowlers*, are divided into two groups, chiefly according to the situation in which they throw out the silken lines for the entanglement of their prey. The first tribe, that of NITIDELÆ, contains species that only prolong these threads from their nests, which are formed under stones in holes of walls, the hollows of leaves, and similar situations. These species much resemble those of the last tribe in their habits; but differ in many points of structure. —In the second tribe, the FILITELÆ, the threads are spread about the places, in which these Spiders prowl in pursuit of their prey. Among these, the *Clotho*, which inhabits Egypt and the South of Europe, is remarkable for the curious habitation which it constructs for its young. This is a kind of limpet-shaped cocoon, about an inch in diameter, of which the circumference has seven or eight festoons; the points of these festoons being

alone fixed to the stone by means of threads, whilst the edges are left free. This singular tent is at first composed of only two folds, between which the Spider takes its station. But subsequently it adds additional folds; and when the period of reproduction arrives, it weaves another apartment, of a softer texture, expressly for the reception of the sacs of eggs, and of the young when hatched. The inside of its habitation is singularly clean. The bags in which the eggs are placed, are about one-third of an inch in diameter; and there are from four to six of them in each habitation. The eggs are not deposited until the end of December or January; and they are enveloped in fine down, to guard them from the cold. The parent creeps in and out beneath the edges of the festoons; and supplies her young with food, for some time after they are hatched. When they are able to dispense with maternal cares, they quit their common habitation, and form separate abodes; and the parent dies within her tent.

758. The last family, SEDENTES, or *Sedentary Spiders*, contains all those species with which we are most familiar, from the annoyance they cause us by the construction of their webs in our houses and gardens.—Of the first tribe, TAPITELÆ,—which construct a sort of tapestried web of close texture, within which they dwell and wait for their prey,—the common *House-spider* is a characteristic example (Fig 442).—The Spiders of the second tribe, ORBITELÆ, have the abdomen larger, softer, and more coloured than the preceding; they make their webs with regular meshes; arranged in concentric circles crossed by straight radii; and they usually remain stationary in the centre, in a reversed position (Fig. 443). Many species, however, construct for themselves a cavity or cell, which is sometimes horizontal and sometimes perpendicular, near the edges of the net. Of this group, the genus *Epeira* is the principal; of which several species abound in our gardens, especially during the autumn. The eggs are deposited by the parent at the commencement of cold weather, in angles of the ceilings of rooms, passages, &c., near gardens; they are enveloped in a loose white web; and are hatched in the spring of the following year. Some species of

Epeira inhabit the neighbourhood of running streams, and feed upon aquatic insects. Another is remarkable as being nocturnal in its habits. The natives of New Holland and the South Sea Islands, when in want of other food, are said to devour a species of Epeira. — The **Retitelæ** bear a close resemblance to the preceding, both in the aspect of their bodies, and in the construction of their webs ; but these are not formed on a regular plan, the threads crossing in all directions and leaving irregular meshes. When their prey is entangled in

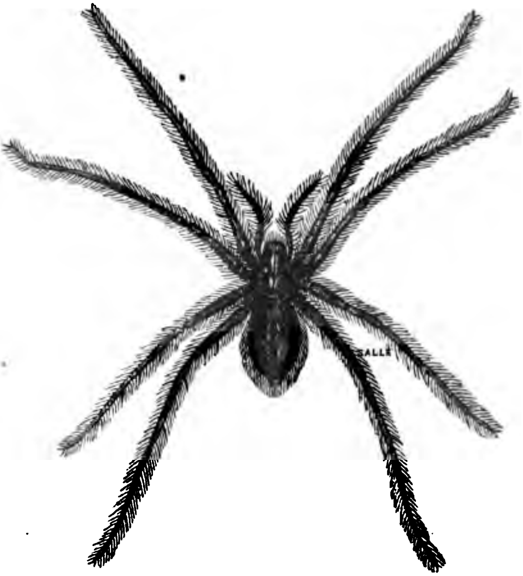

Fig. 442.—Tegenaria domestica, or House-Spider.

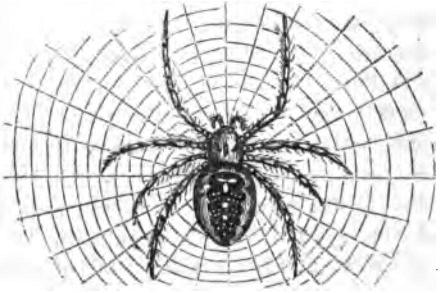

Fig. 443.—Epeira diadema.

their web, they whirl threads around it, so as to secure it effectually. They take great pains in the preservation of their eggs, and do not leave them until they are hatched. In one common species which frequents our dwellings, the female gums her eggs into a rounded body, unprotected by a cocoon; and this she bears about in her jaws. Other species live out of doors, and construct their webs among trees. To this group belongs the *Malmignatte*, an inhabitant of Tuscany and Corsica; which is reputed to be very venomous.

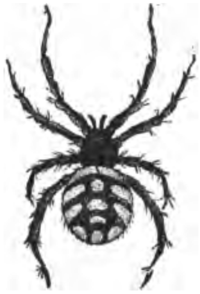

FIG. 444.—MALMIGNATTE.

759. The last family of Araneidæ, the NATANTES, or *Water-Spiders*, closely resembles the preceding in structure; and should scarcely, perhaps, be separated from it. They live entirely upon or beneath the water; and are enabled, by the hairiness of their bodies, especially on their under surface, to entangle and carry down with them a supply of air for their respiration. One very interesting species, the *Argyroneta aquatica*, or Diving Spider, not only employs its silken threads to entangle its prey, but forms with it an oval bag, of such close texture that it is impervious to air or water; this is attached by threads to aquatic plants, at a considerable depth below the surface; and its under side is open, like that of a Diving Bell; so that the Spider can freely pass in and out. Here it retreats to devour its prey; and here, too, it constructs its egg-case, and even passes the winter. The mode in which it fills this with air, when about to take up its residence in it, is very curious. The hairs upon its body entangle so large a quantity of air, as to render it quite buoyant; in order to descend to its bell, therefore, it is obliged to creep along the stems of aquatic plants; and

445.—DIVING SPIDER.

when it has arrived there, it gets beneath its lower edge, and allows the bubbles of air which it had entangled to ascend into it. Then returning to the surface of the water, it brings down a fresh supply of air; and in this manner it gradually fills the bell, which then presents a beautiful silvery or glistening appearance, when seen beneath the surface of the water. This process is strikingly analogous to that, which was first employed to renew the air in Diving Bells; barrels of air being sent down by means of weights, and their air being allowed to pass into the bell, by means of a flexible pipe, when they had been sunk to a lower level.

760. Section II. Pedipalpi. This section is distinguished by the large size of the palpi, which resemble extended arms, and which are furnished at their extremities, either with moveable hooked claws, or with a pair of pincers, composed of two fingers, one fixed and the other moveable, like those of Crabs and Lobsters. The abdomen is composed of very distinct segments; and is destitute of spinnerets at the tip. The entire body is encased in a hard skin. The cephalothorax is composed of a single piece, and is furnished with six or eight ocelli or eyelets. The number of pulmonary sacs is *four* in one of the two families of which the section is composed, and *eight* in the other. In the first of these families, Thelyphonidæ, the general form is that of the Spiders; so that the species included in it are commonly ranked as such. They are, however, at once distinguished by the large size of the palpi, and by the absence of spinnerets. They differ from the Scorpions, on the other hand, in the form of the abdomen; and in the absence of a sting at its extremity. The tarsi of the two fore-legs differ from the others in a remarkable degree; being composed of numerous joints, so slender and prolonged as to resemble threads, and being destitute of the usual hook at its extremity. These Arachnida inhabit only the hottest parts of Asia and America; very little is known of their habits.

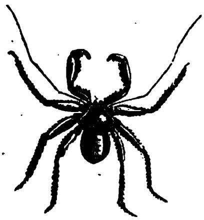
Fig. 446.—Phrynus Reniformis, reduced.

761. With the characters of the second family, SCORPIONIDÆ, or the *Scorpion* tribe, we are much more familiar. It is especially distinguished from the preceding by its eight breathing-pores; but also by its long-jointed abdomen (the hinder part forming what is commonly called the tail), terminated by a venomous claw or sting. The abdomen is composed of twelve segments; six of which are broad, forming the posterior part of the body, whilst the other six form the tail. Between the thorax and abdomen there is no distinct division. In these particulars, — the evident division of the body into segments, the want of separation between the thorax and abdomen, the multiplication of the respiratory sacs,—as well as in others, the Scorpionidæ show an evident approach towards the Myriapoda. The Arachnida of this tribe inhabit the warm countries of both hemispheres, living on the ground, hiding themselves under stones or other bodies (generally in dark and cool places), and sometimes taking up their abode in the interior of houses. They run quickly, and curve the tail over the back. They can turn it in all directions, and employ it as a weapon of offence or of defence. Their usual food consists of Wood-lice and various Ground-Insects, such as Carabi, Weevils, Orthoptera, &c.; these they seize with their pincer-like palpi, and then prick them with their stings, so as to render them powerless before proceeding to devour them. They are also particularly fond of the eggs of Spiders and Insects. It is only in the larger species of Scorpion, which are five or six inches long, and inhabitants of tropical countries, that the poison is sufficiently powerful to do any serious mischief to Man; and although the effects of the sting

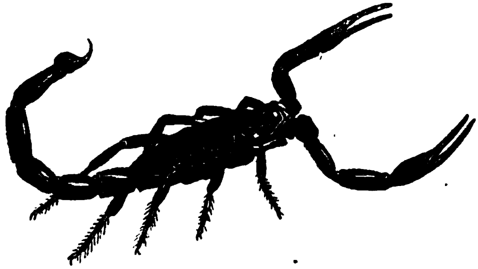

FIG. 447.—SCORPION.

of these are severe, they are seldom, if ever, fatal, except in persons previously unhealthy. It is not generally known, that a small species of Scorpion exists in our own country, as well as on the Continent of Europe; and this has afforded to European Naturalists an opportunity of watching its habits. The female resembles that of the Spiders in her attention to her young; these she carries on her back for several days, at first not quitting her abode; and she afterwards takes care of them for the space of a month, by which time they are enabled to shift for themselves.

ORDER II.—TRACHEARIA.

762. THE Arachnida of this order present a much stronger resemblance to the class of Insects, than do any of the preceding; for they are characterised not merely by the nature of their respiratory organs—which consist of ramified tracheæ, instead of pulmonary sacs—but also by the imperfect development of the circulating apparatus, as well as by a certain degree of metamorphosis, which has been observed in several of them. They may be divided into three families, according to the form of the thorax and abdomen,—these characters being preferred, on account of their being more easily recognised, in the minute animals of which the group consists, than those founded on the structure of the mouth and the mode in which the food is obtained. These families are;—I. The PSEUDO-SCORPIONIDÆ, or *False-Scorpions*, are so named from the strong resemblance which some of them bear to the preceding group; these have the abdomen very distinct from the thorax, and marked with rings; and are furnished with large palpi, which are either formed like feet (Fig. 448), or furnished with pincers (Fig. 449):—II. The PHALANGIDÆ, or *Harvest-men*, which may be regarded as representing the Spiders in the Trachеary Order; they have the thorax and abdomen united into one mass, but the latter does not exhibit any division into rings; the palpi are thread-like;—and III. The ACARIDÆ, or *Mites*, which have the abdomen united to the thorax, but altogether unmarked by rings (Fig. 452).

763. The general form and aspect of the PSEUDO-SCORPIONIDÆ will be best understood from the accompanying figures, which represent two of the principal species. The *Galeodes* is found in the warmer temperate and the tropical regions, principally of the Old World. They run with great quickness, erect their heads when surprised, show signs of resistance, and are reputed to be venomous. The *Chelifer* strongly resembles a small Scorpion deprived of its tail; and one species, which inhabits herbaria, old books, &c.,—feeding upon the minute insects which frequent such situations, is commonly known under the name of Book-Scorpion. It runs quickly, and often sideways, like the Crabs or the Laterigrade Spiders. The eggs are united into a mass, which is said to be carried about under the abdomen.

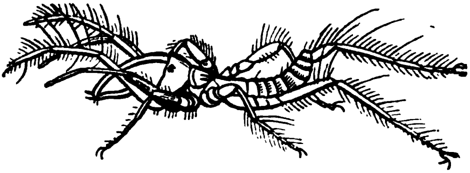

FIG. 448.—GALEODES INTREPIDA.

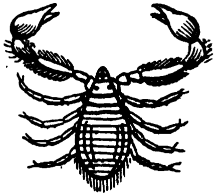

FIG. 449.—CHELIFER FASCIATUS.

764. Here has been placed, by many Naturalists, a very curious group, the PYCNOGONIDÆ; which departs very widely from the other Arachnida, both in the structure of the body, as well as in the residence, which is exclusively marine. It appears to be destitute of any special Respiratory apparatus; and cannot, therefore, be referred with certainty either to this class or to the Crustacea, by characters derived from the mode in which this function is performed. On the whole, however, its analogies seem to be rather with the latter class; with which, therefore, it will be described (§ 815). It may be regarded as connecting the Arachnida and Crustacea.

765. The PHALANGIDÆ, or Harvest-men, have two thread-like palpi, terminated by a small hook; the legs are long and slender, and when detached from the body, they show signs of

irritability for a few moments. The majority of them live upon the ground, upon plants, or at the roots of trees, and are very

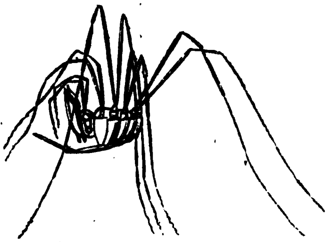

FIG. 450.—PHALANGIUM CORNUTUM.

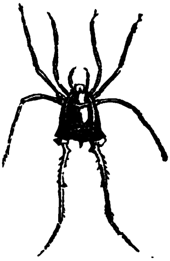

FIG. 451.—GONYLEPTES ACANTHURUS.

active in their movements; others hide themselves between stones, or in moss, and are less agile.

766. The ACARIDÆ, or *Mites*, have the mouth formed rather for suction than for mastication; its various pieces not being separate, as in the other Arachnida, but more or less enveloped in a sort of sheath formed by a prolongation of the lower lip; the maxillary palpi, however, are generally free, and their extremities are commonly armed by a small pair of pincers. Some of these animals have four or two eyes; others have only a single one; and there are several which do not possess any. They are nearly all of very small size, and multiply with great rapidity. Many of them come forth from the egg with only six legs, and may be considered to bear, in this state, a strong resemblance to parasitic insects; they do not acquire their additional pair until after the first moult, which thus becomes a sort of metamorphosis. The Acaridæ are very widely,—in fact universally,—distributed. Some of them are of wandering habits; and amongst these, some are found under stones, leaves, the bark of trees, in the ground, the water, or upon various articles of food, such as meat and old dry cheese, and upon putrid animal matters. Others subsist as parasites upon the skin, and in the flesh of different animals; often greatly weakening them by their excessive multiplication, and producing most violent itching. Other kinds of Mites are parasitic upon Insects; and

many Beetles which feed upon decaying substances, are entirely covered by them. The *Acari*, or *True Mites*, have the legs adapted for walking; and some of them are of active habits. The common *Cheese-Mite* is familiar to every one; and there are many other species which nearly resemble it in structure and habits, but which feed upon different substances. To this group belongs a small species, which appears to be the occasion of one of the most disgusting diseases of the skin,—the itch. It is scarcely visible to the naked eye; but when examined under the microscope, it is seen to have an oval body; a mouth of conical form, armed with several bristles; and eight feet, of which the four anterior are terminated by small suckers, that enable it to adhere firmly to any solid bodies, whilst the four posterior are terminated only by bristles. Some of this Acari have the power of spinning webs, and are commonly ranked with the Spiders; one of these is well-known as the Red Spider in hot-houses, where it greatly injures the plants by covering the leaves with its webs.—The *Riciniæ*, commonly known as *Ticks*, are usually destitute of eyes, but have the mouth provided with lancets, that enable them to penetrate more readily the skins of animals whose blood they suck. They are usually of a flattened, round, or oval form; but they often acquire a very large size by suction, and become distended like a blown bladder. They are found in thick woods, abounding in brushwood, briars, &c., and attaching themselves to plants with the two fore legs. They fasten upon dogs, cows, horses, and other quadrupeds, and even upon the tortoise; and they bury their suckers (which are often furnished with minute recurved hooks,

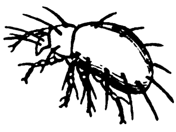

FIG. 452.—ACARUS DOMESTICUS, OR CHEESE-MITE, magnified.

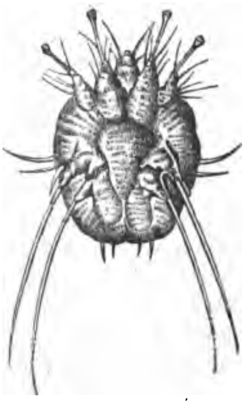

FIG. 453.—SARCOPTES SCABIEI, OR ACARUS OF THE ITCH.

as in the *Ixodes*, Fig. 454,) so firmly in their skin, that they can hardly be detached by force,—the portion of skin to which they are attached coming away with them. It is probably the young of a species of this group, which is commonly known as the *Harvest-Bug;* this is very common in the autumn, upon grass or other herbage; and insinuates itself into the skin at the roots of the hair, producing a very painful irritation. In this state it possesses only six legs.—Lastly, there is a tribe of Acaridæ, the *Hydrachnæ*, in which the legs are covered with hairs, in such a manner as to adapt them for swimming; these are all, during a part of their lives at least, parasitic upon various Water-Insects, such as the Dytiscus, the Nepa, &c. These Water-Mites undergo a more complete metamorphosis than any of the preceding; for the larvæ have a very large head, and six legs; whilst the pupæ have but a single pair of legs, with which they attach themselves to the bodies of insects, and present the appearance of an oval bag with a narrow neck.

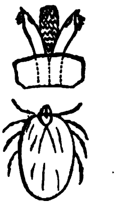
FIG. 454. — IXODES PLUMBEUS, AND ITS BEAK, magnified.

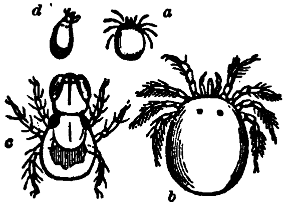

FIG. 455.—*a*, HYDRACHNA GLOBULUS; *b*, magnified; *c*, young larva; *d*, pupa.

CHAPTER X.

CLASS OF CRUSTACEA.

767. CRUSTACEA are Articulated animals, respiring by *branchiæ* or external gills, or by the general surface, and possessing a circulating apparatus, and separate sexes. Crabs and Lobsters are the types of this group; but a great number of animals of a much less complicated structure, and of a different external form, are also classed with these; for as we descend the natural series formed by these animals, we see the same general plan of structure gradually modified and simplified. The lowest Crustacea are even so imperfect, that they can only exist, attached like parasites, on other animals: whence most Naturalists have placed them with the Intestinal Worms.

768. The tegumentary skeleton of Crustacea generally possesses a very considerable degree of firmness. It has nearly always a stony hardness; and indeed contains a very considerable proportion of carbonate of lime. We may look upon this solid envelope as a kind of epidermis; for beneath it we find a membrane like the true skin of higher animals; and at certain times it detaches itself and falls off, in the same manner as the epidermis of Reptiles separates itself from their bodies (§ 471), and as we have also seen the enveloping membrane of the larvæ of Insects renew itself several times. We can easily understand the necessity of this change, in animals whose whole bodies are inclosed in a solid case; which, not being able to grow like the interior parts, would oppose an invincible obstacle to their development, if it could not be thrown off, as soon as it has become too small to lodge them commodiously. Thus the Crustacea change their skin during the whole time of their growth; and it would seem that the greater part of these animals grow during their whole life. The manner in which

they free themselves from their old shell is exceedingly singular. In general they manage to get out of it without occasioning the least change in its form; and when they have quitted it, the whole surface of their body is already clothed in a new casing,—which, however, is still soft, and does not acquire its requisite solidity for some days.

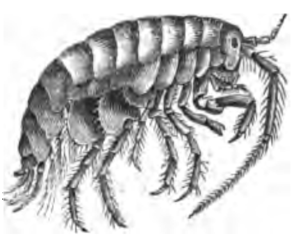
FIG. 456.—SANDHOPPER.

769. The body of Crustacea is composed of a series of rings, more or less distinct. Sometimes most of these segments are simply articulated one with the other, so as to admit of a considerable degree of motion, as in the Sandhopper; sometimes they are nearly all soldered together, and are only distinguished by furrows situated at their line of juncture; lastly, in other cases, their union is still more close, and it is only by analogy that we are led to consider the trunk, resulting from their juncture, as made up of several rings, rather than of one only. Hence result, as we can easily understand, very great differences in the form of these animals; and if we compare with each other a Woodlouse (Fig. 457), a Sandhopper (Fig. 456), and a Crab (Fig. 458), we might be at first led to believe them formed according to types entirely different; but a deeper study of their structure shows, that the composition of their tegumentary skeleton is essentially the same, and that the differences lie almost entirely in this,—that most of the rings being quite distinct and moveable in the Woodlouse, are grown together in the Crab, and that certain analogous parts do not present the same proportions in both animals. Thus in the Woodlouse and Sandhopper we find a distinct head (c) followed by a thorax composed of seven rings similar to each other (t^1 t^7), and each

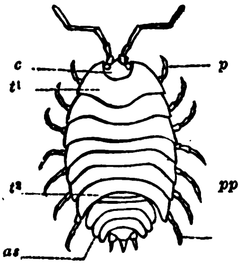

FIG. 457.—ONISCUS, OR WOODLOUSE.

ring provided with a pair of legs (*p*, *pp*,) : and at the posterior part of the body we see an abdomen, also composed of seven segments (*as*), whose size diminishes rapidly, but whose form is nearly the same as in the thorax. In the Crab (Fig. 458), on the contrary, the head is not separated from the thorax; and it forms, with the whole middle part of the body, but a single mass, covered by a large solid buckler called the *carapace*. The abdomen, at first, escapes observation; for it is bent down under the thorax, and is of small size. Yet it is easy to show, that in the Crab, as in the Woodlouse, there are seven very recognisable thoracic rings, and that the carapace is not a new part introduced instead of the former, but merely the dorsal portion of one of the rings of the head, so extremely developed that it has encroached upon all the neighbouring rings.

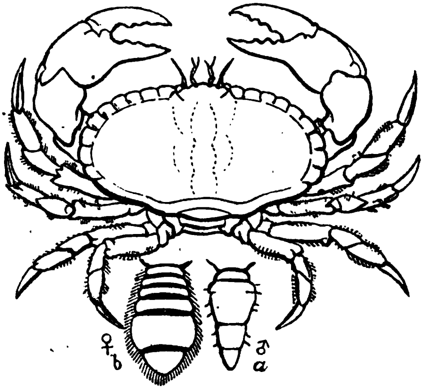

FIG. 458.—CANCER PAGURUS, *Linn.*, with the tail of the male, *a* ; and of the female, *b*.

770. In other animals of the same class, the general form of the body differs still more widely from those of which we have just spoken. Thus the *Limnadiæ* are inclosed between two oval shields, joined like the valves of an Oyster, and it is only after having raised this moveable cuirass, that we first perceive the annular structure of the body (Fig. 490); the *Cypris* (Fig. 495), which abounds in stagnant waters, presents a similar arrangement: but the rings of which its body is composed, are still more difficult to recognise. Lastly, we may advert to the *Lerneæ*, which at their adult age present the strangest forms; but which, in the earlier part of their existence, possess a regular annular structure (Figs. 501, 502). This comparative study of

the tegumentary skeleton is of great interest as a department of Philosophic Anatomy; one of whose most important branches has reference to those modifications, to which Nature subjects the same organic elements, in order to adapt them to various purposes, and to create different animals from analogous materials; but the limits we have assigned ourselves, do not permit us to dwell longer on this subject.

771. The lateral appendages of the different rings constituting the body, are in general very numerous, and present considerable differences in their conformation and uses;—both when we consider those in the different parts of the same individual, and when we compare them in distinct species. Those of the first pair are generally subservient to the animal functions, and support the eyes or constitute the antennæ; the next surround the mouth, and serve for the prehension or division of the food; those of the middle part of the body constitute the legs for locomotion; and those which are placed behind have various uses, but are generally subservient to respiration or reproduction; lastly, this long series ordinarily terminates by one or several pairs of members, which serve as fins.

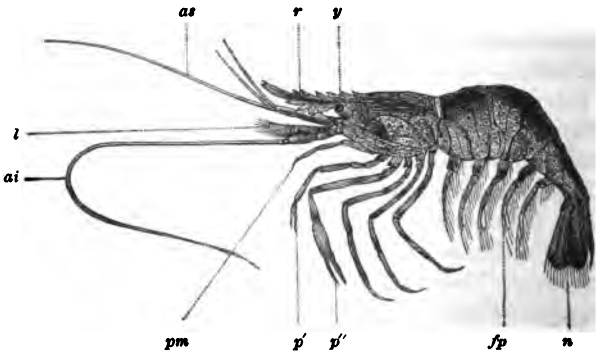

FIG. 459.—PRAWN:—*as*, antennæ of the first pair; *ai*, antennæ of the second pair; *l*, laminar appendage covering its base; *r*, rostrum, or frontal prolongation of the carapace; *y*, eyes; *pm*, external foot-jaw; *p′*, first thoracic member; *p″*, second thoracic member; *fp*, false legs, or swimming members, of the abdomen; *n*, tail-fin.

772. The head, or rather the cephalic portion of the body, carries the eyes, the antennæ, and the appendages of the mouth.

It is sometimes divided into several distinct rings, as in the *Scillæ;* but in general there is no separation, and it is formed of a single piece, which seems to represent seven segments joined together. Sometimes it is moveable, and distinct from the thorax (Fig. 458); sometimes, on the contrary, it is joined to this second part of the body, which in its turn is composed of distinct rings, articulating with each other in some species, but in others united into a single mass.

773. Of the antennæ, there are nearly always two pair; and they are generally thread-like, and very much elongated (Fig. 459, *as* and *ai*). The legs originate by pairs from the different thoracic rings; and they often amount to seven pairs, as for example in the Woodlouse (Fig. 457), and Sand-hopper (Fig. 466); but in other instances, as we see in Crabs (Fig. 458) and Cray-fish (Fig. 471), their number is reduced to five pairs; those appendages, which in the former constituted the four anterior legs, being subjected in the latter to other uses, and transformed into organs of mastication (§ 775). There are also very great differences in their structure: in some Crustacea they are leaf-like, membranous, and fitted for swimming only (Fig. 490); in others they look like little columns jointed together, and adapted for walking only; in others, while yet remaining appropriate to this last kind of locomotion, they are destined to be used also as so many little spades for digging in the earth, and then they are enlarged and laminated at the end (Fig. 460); lastly, in others, they end in pincers, and thus become instruments of prehension, at the same time that they fulfil their ordinary functions in locomotion (Figs. 471 and 505). In swimming Crustacea, such as Cray-fish, Lobsters, Prawns, &c. (Fig. 459), the abdomen generally attains a considerable development, and ends in a large fin, in such a manner as to become the principal agent in

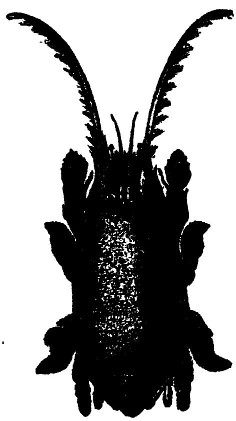

FIG. 460.—HIPPA.

locomotion; but in those which are destined to walk rather than to swim, this part is generally very small and bent under the thorax. In the Crabs, for instance, this portion of the body is reduced to almost nothing, and forms a sort of moveable appendage, which is seen on the inferior surface of the body beneath the legs (Fig. 458).

774. The Nervous System of Crustacea consists of a double series of ganglia, situated on the ventral surface of the body, near the central line. In general their number corresponds to that of the distinct segments composing the body; and the first pair is always placed on the head, in front of the œsophagus, where it forms a sort of brain. The arrangement of the thoracic and abdominal ganglia, however, varies considerably; sometimes they are placed at equal intervals, and form, with their cords of communication, a chain extending from one end of the body to the other; sometimes they approach one another more or less closely; and sometimes they are united, forming a single mass, situated about the middle of the thorax (Fig. 461, *t*). It may be remarked that this concentration of the nervous system becomes more and more complete, as the animal acquires a higher organisation. The Crustacea have in general but very limited faculties; and none among them present much to interest, as to their habits. The eyes are formed nearly in the same manner as in Insects; sometimes they are simple, but in general they are compound; and in all the most perfect Crustacea, these

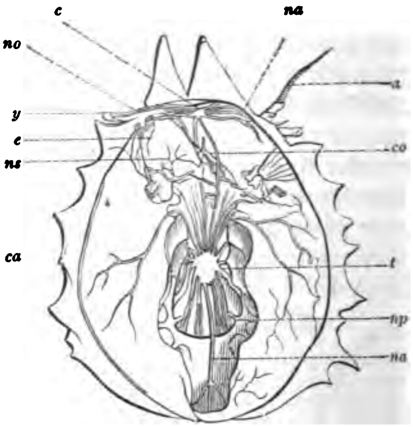

FIG. 461.—NERVOUS SYSTEM OF CRAB (*Maia*): *ca*, upper part of the shell laid open; *a*, antennæ; *y*, eyes; *e*, stomach; *c*, cephalic ganglion; *no*, optic nerves; *co*, œsophageal collar; *ns*, stomato-gastric nerves; *t*, thoracic ganglionic mass; *np*, nerves of the legs; *na*, abdominal nerve.

organs are situated on moveable footstalks (Fig. 462); an arrangement which we do not see in any other division of Articulated animals.—In many Crustacea, there is an apparatus for hearing, situated at the base of the external antennæ, and composed of a small membrane, under which we find a sort of vestibule filled with liquid, and inclosing the termination of a particular nerve. This constitutes the simplest form of an Auditory apparatus. (Anim. Physiol. § 512). We know nothing positive concerning the senses of Smell and Taste in these animals.

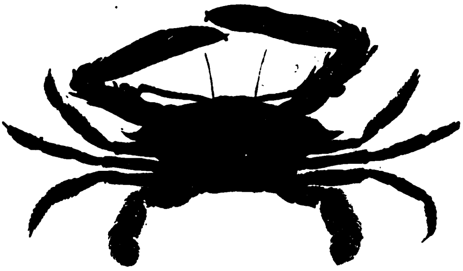

Fig. 462.—Podophthalma.

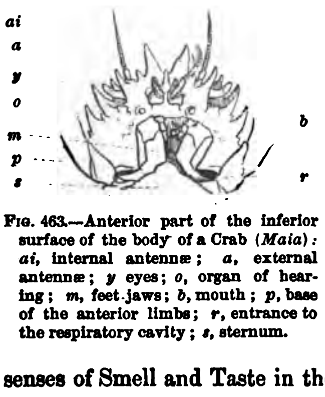

Fig. 463.—Anterior part of the inferior surface of the body of a Crab (*Maia*): *ai*, internal antennæ; *a*, external antennæ; *y* eyes; *o*, organ of hearing; *m*, feet-jaws; *b*, mouth; *p*, base of the anterior limbs; *r*, entrance to the respiratory cavity; *s*, sternum.

775. Most Crustacea subsist on animal substances; but they present great differences in their regimen, some being only nourished upon liquid matters, whilst others feed upon solid aliment; and we observe corresponding differences in the formation of their mouths. In masticating Crustacea there is in front of this opening a short transverse lip, followed by a pair of mandibles, by an inferior lip, by one or two pairs of jaws properly so called, and generally by one or three pairs of auxiliary jaws, or feet-jaws, which serve principally for the prehension of food

(Fig. 472). In suctorial Crustacea, on the contrary, the mouth is prolonged into a sort of beak, or trunk, as we have already seen in Insects of the same habits. In the interior of this tube, we find thin and pointed appendages, which perform the office of little lancets; and on each side we commonly see organs, which are analogous to the auxiliary jaws of masticating Crustacea, but which are so formed as to serve to fix the animal on its prey.

776. The digestive canal extends from the head to the posterior extremity of the abdomen; and is composed of a very short œsophagus, a large stomach (*e*, Fig. 466) generally armed interiorly with powerful teeth, of a small intestine, and of a rectum. In some Crustacea, the bile is secreted by biliary vessels, like those of Insects; but in general there is a very voluminous liver, divided into several lobes, and composed of a

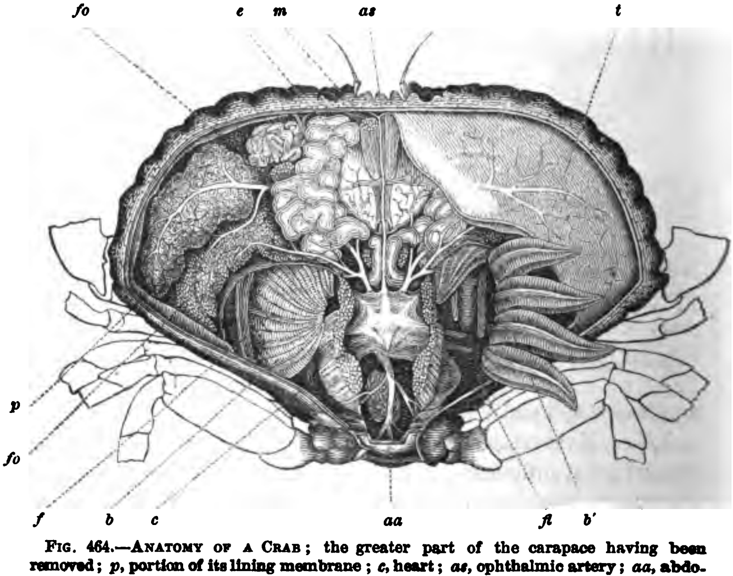

Fig. 464.—Anatomy of a Crab; the greater part of the carapace having been removed; *p*, portion of its lining membrane; *c*, heart; *as*, ophthalmic artery; *aa*, abdominal artery; *b*, branchiæ in their natural position; *b′*, branchiæ turned back to show their vessels; *fl*, lower portion of the shell; *f*, appendage of the foot-jaw; *e*, stomach; *m*, muscles of the stomach; *fo*, liver.

multitude of small tubes terminating in follicles, and grouped round a ramified excretory canal, whose extremity empties itself on each side into the intestine near its commencement (*fo*, Fig. 464.)

777. We know as yet nothing of the manner in which the chyle passes from the intestine into the circulating apparatus. The blood is colourless, or slightly tinged with blue or lilac; and coagulates easily. This liquid is put in motion by a heart, situated on the median line of the back, and composed of but a single cavity of variable form (Fig. 465, *a*). Its contraction propels the blood into the arteries, which distribute it to all parts of the body. The veins are very incomplete, and are formed chiefly by passages left between the different organs, and lined by a thin layer of areolar tissue; they end in large cavities near the base of the legs (Fig 466, *s*,) from which the blood is conducted to the respiratory organs, whence it returns to the heart by very distinct canals termed *branchio-cardiac* vessels.

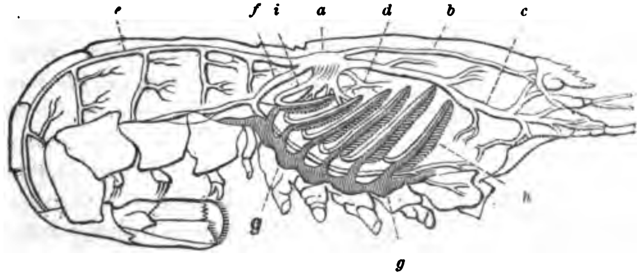

FIG. 465.—CIRCULATING APPARATUS OF LOBSTER; *a*, heart; *b* and *c*, arteries to the eyes and antennæ; *d*, hepatic artery; *e* and *f*, arteries to thorax and abdomen; *gg*, venous sinus; *h*, gills; *i*, branchial veins.

778. Crustacea are almost all essentially aquatic; their respiration is nearly always effected by gills; and when these organs are absent, their place is supplied by the skin of certain parts of the body, generally of the legs. In other respects, the arrangement of the respiratory apparatus varies considerably. Thus in the Crabs, Cray-fish, and all other Crustacea of analogous organisation, the gills consist of a considerable

number of pyramids,—each composed either of a number of minute cylinders placed like the hairs of a brush, or of little lamellæ piled one on the other like the leaves of a book.—These organs are fixed by their extremities to the inferior border of the arch of the flanks (Fig. 466); and are inclosed in two large cavities, situated at the side of the thorax and shut in between the carapace and the arch just mentioned, an arrangement which is not found in the other divisions of this class. The respiratory cavity communicates with the exterior

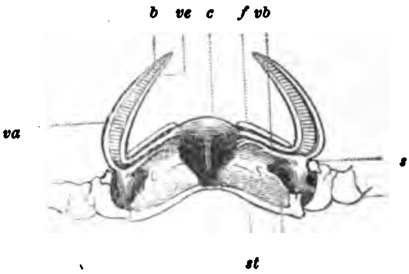

Fig. 466.—Vertical section of a Crustacean, showing the course of the blood; *c*, heart; *s*, venous sinus; *va*, vessels conducting the venous blood to the gills; *ve*, vessels which collect the aërated blood from the capillaries of the gills; *vb*, branchiocardiac vessels; *f*, carapace; *st*, sternum.

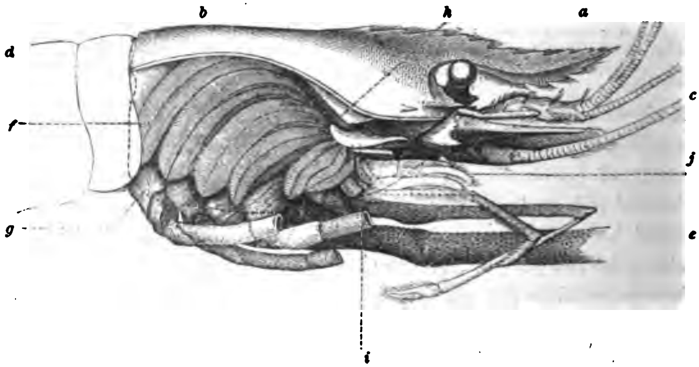

Fig. 467.—Respiratory Apparatus of Prawn; *a*, rostrum or beak; *b*, carapace; *c*, base of antennæ; *d*, base of abdomen; *e*, base of legs; *f*, gills; *g*, dotted line, marking the turned-in border of the portion of the carapace that covers in the gills, which has been removed in this preparation; *h*, canal for the exit of the water from the respiratory chamber; *i*, its valve; *j*, its extremity.

by two openings; that which serves for the entrance of the water is situated between the base of the legs and the side of the carapace; the other, destined for the exit of the water, is placed at the sides of the mouth (Fig. 467). The renewal of the water in contact with the gills, is effected by the movements of a large valve, situated near this last opening, and formed by lamellated appendages of the second pair of jaws (Fig. 467, *i*). In other Crustacea, the *Scilla* for instance, the gills are formed of feathery tufts; and instead of being inclosed in the thorax, they float freely on the exterior, and are fixed to the abdominal members. In others, as the Sandhoppers, the gills are replaced by membranous vesicles fixed at the base of the legs, beneath the thorax. Lastly, in the Isopod Crustacea, the respiration is effected by means of false abdominal legs, which present a leaf-like and membranous aspect.

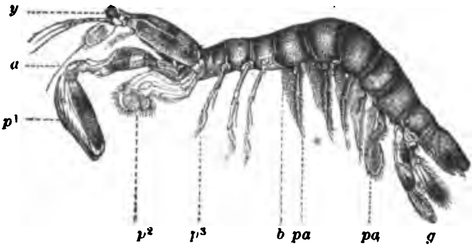

FIG. 468.—SCILLA; *y*, eyes; *a*, antennæ; p^1, first pair of legs; p^2, second pair of legs; p^3, three last pairs of thoracic legs; *pa*, abdominal pro-legs; *b*, gills; *g*, fin-like members.

779. A small number of these animals are formed to exist in air; but they constitute an exception to what has been said, relative to the difference in the structure of the breathing apparatus of terrestrial and aquatic animals: for, instead of being provided with lungs or tracheæ, they respire by gills like the former; but these organs are placed in such a manner, as to be surrounded by that degree of moisture, which is necessary for the exercise of their functions. The *Land-Crabs*, which are met with in different parts of the globe, but which chiefly abound in the Antilles, offer a remarkable example of this anomaly. Instead of living in the water like ordinary Crustacea, these animals are terrestrial;

and although provided with gills, some among them are speedily suffocated by submersion in water. Indeed, their respiration is so active, that the small quantity of oxygen dissolved in the water cannot suffice for their wants; but in the air they find this gas in abundance; and an arrangement similar to that which we have met with in certain Fish (§ 538), permits them to remain out of the water without their gills becoming so dry, as to be unfit to perform their functions. Sometimes there is, at the bottom of the respiratory cavity, a sort of basin, destined as a reservoir for the water necessary to supply the requisite moisture to the gills. In other instances, we find in the lower arch of this cavity a spongy membrane, which seems to serve the same purpose. Most of these Land-Crabs commonly inhabit moist woods, and hide themselves in holes which they dig in the soil; but the localities which they prefer vary according to their species. Some dwell in low marshy lands, near the sea; others in wooded hills far from the shore; and these last at certain periods quit their habitual dwellings for the sea. The Woodlice also are terrestrial Crustacea, whose respiration is effected by means of leaf-like plates, which are situated under the abdomen, and which, in other animals formed nearly on the same plan, fulfil the functions of gills.

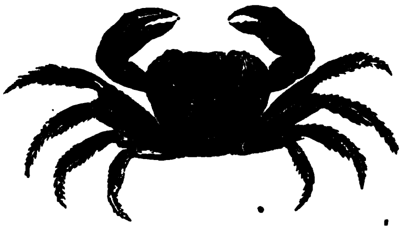

FIG. 469.—LAND CRAB.

780. All Crustacea are oviparous. The female is generally distinguished from the male by the more enlarged form of the abdomen; and after having laid the eggs, she carries them for some time, suspended under that part of her body, or even inclosed in a sort of pouch, formed by the appendages to the legs. Sometimes the little ones swim about in this pouch, and remain there until they have undergone their first moult. The young do not in general undergo true metamorphoses; but sometimes they acquire, with advancing age, a larger

number of legs; there are some which change their form completely during the first part of their life. This is the case, for example, with the common Crab, whose early condition is represented in the accompanying figure. It is remarkable, however, that in other animals of the same Order, such as the Cray-fish, the change of form is so inconsiderable, as not to deserve the name of metamorphosis. Hence we perceive that the degree of this change cannot be employed as a character in the subdivision of the Class, as we have seen that it may be in Insects. Of a large proportion of Crustacea, however, the early form is unknown. The metamorphoses of some of the lower tribes are even more extraordinary than those of the higher (Figs. 496 and 497, 501 and 502); being frequently such, as appear to remove the adult altogether from the class, to which the larva evidently belongs.

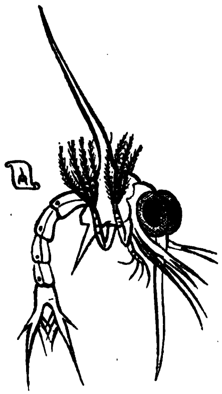

FIG. 470.—EARLY FORM OF THE CRAB.

781. The early condition of many of the higher Crustacea bears a strong resemblance to the permanent forms of the lower. This is in no point more remarkable, than in the character of the respiratory apparatus. Thus in the earliest period of the development of the *Astacus fluviatilis*, or River Cray-fish, no trace of gills can be discovered; but as the embryo within the egg approaches maturity, temporary gills are developed in the form of leaf-like expansions, occupying the situation of the extremities of the maxillary appendages, which are the first developed of all the members. These soon subdivide, and one part assumes a cylindrical form, and seems no longer to belong to the apparatus; whilst branchial filaments begin to appear on the other—which are subsequently prolonged into complete gills. During this interval, the thoracic extremities have made their appearance; and they also become furnished with branchial appendages. At a subsequent time, a narrow groove or furrow is seen along the

under edges of the thorax; the margins of which, after no long period, are prolonged so as to meet each other and enclose the gills,—openings being left for the entrance and exit of water, which are at first large, but which subsequently become contracted to the proper size.

782. The Class of Crustacea may be divided into three natural groups or Sub-Classes, characterised by differences in the conformation of the mouth, as follows:—

I. MAXILLOSA, or *Masticating* Crustacea, whose mouth is furnished with mandibles and maxillæ adapted for mastication.

II. EDENTATA, Toothless or *Suctorial* Crustacea, whose mouth is composed of a tubular beak armed with suckers.

III. XYPHOSURA (so named from the *Sword-like* appendage with which they are furnished, Fig. 505), whose mouth has no appendages peculiar to it, but is surrounded by legs, whose bases perform the office of jaws.

783. The group of MAXILLOSA comprehends the greatest part of the class; and includes all those, whose organisation is most complicated and perfect. These Crustacea do not live on the juices of other animals, as do those constituting the suctorial group; but they are habitually nourished on solid food. They vary greatly in external form, in their number of legs, and in the structure of their respiratory apparatus; and they may be divided by these characters into four Sections, containing nine Orders.—

A. The *first* Section, PODOPHTHALMA, includes all those having the eyes mounted upon foot-stalks, and moveable. They are almost always furnished with distinct branchiæ; their feet are partly formed for walking, and partly for prehension; and the thorax is covered with a *carapace*, formed by the great development of one of the rings. This Section includes the two first Orders:—

I. DECAPODA, possessing five pairs of thoracic extremities, and having the gills enclosed in a special respiratory cavity, on each side of the thorax.

II. STOMAPODA, having the gills external, and a variable number of extremities.

B. The *second* Section, Edriophthalma, consists of those Crustacea, whose eyes are *sessile* (that is, not mounted on a foot-stalk), and whose branchiæ are not distinct organs, but are united with the extremities, which are commonly seven on each side, and adapted for walking. This Section contains the three succeeding Orders :—

III. Amphipoda, in which the thoracic members are subservient to respiration; and which have the abdomen well developed, and furnished with six pairs of appendages.

IV. Læmodipoda, in which there is the same provision for respiration, but which have the abdomen undeveloped.

V. Isopoda, in which the abdomen is well developed, and has members, similar in form to the rest, subservient to respiration.

C. The *third* Section, Branchiopoda, is characterised by the absence of any special organs for respiration; their place being supplied by the flattening of the anterior pair of legs into thin plates, which are subservient to that function. This Section contains two Orders :—

VI. Phyllopoda, in which the body is either shell-less, or enclosed in a simple carapace, and furnished with a large number of appendages.

VII. Cladocera, in which there is a carapace in the form of a bivalve shell.

D. The *fourth* Section, Entomostraca, is composed of Crustacea in which there are no branchiæ, nor any organs destined to supply their place. The eyes are sessile, and are commonly united into a single mass. This Section also contains two Orders :—

VIII. Ostrapoda, which has the body inclosed in a sort of shield resembling a bivalve shell.

IX. Copepoda, in which there is no such envelope.

It is in the Order Isopoda, that we find, in the equality of the segments and of their appendages, as well as in the aerial respiration of many species, the nearest approach to the class MYRIAPODA; and in some members of the Entomostracous section, we find a considerable approximation to the higher ROTIFERA.

SECTION A.—PODOPHTHALMA.

ORDER I.—DECAPODA.

784. In this Order we find the highest general organisation, the largest size, and the most varied habits, which we anywhere meet with among Crustacea; it is the one most useful to Man; and also most interesting to the Naturalist. The *Lobsters*, *Crabs*, *Cray-fish*, *Prawns*, *Shrimps*,—in fact, nearly all the species that are ever used as food,—belong to it. Their growth is slow; but they ordinarily live a long time. Their habits are mostly aquatic; but, in consequence of the manner in which their gills are inclosed, none of them are killed at once by being withdrawn from the water; and some of them pass the greatest part of their lives in air. They are naturally voracious and carnivorous: and the first pair of legs is transformed into a pair of powerful claws, by which they seize their food and convey it to the mouth,—the claw of one side usually having a sharp edge for cutting, whilst that of the other is provided with a blunt rounded edge for bruising. The form and size of the claws, relatively to the rest of the extremities, varies greatly in the different species; thus in the *Cray-fish* (Fig. 471), they only seem like legs somewhat enlarged; whilst in the *Crabs* (Fig. 475), they commonly seem to be distinct organs. It is in this group, that we find the mouth furnished with the most complicated set of appendages; and we may trace in these a gradual transition from the form of jaws to that of legs. This is shown in the accompanying figures, which represent the under surface of the Cray-fish, and the series of feet-jaws separately displayed.—This Order is divided into three sub-orders,

according to the development of the abdomen; these are:—I. The Brachyoura, or *short-tailed* Decapods, to which the name of *Crabs* is commonly applied;—II. The Macroura, or *long-tailed*, such as the *Lobster*, *Cray-fish*, &c.;—and III. The

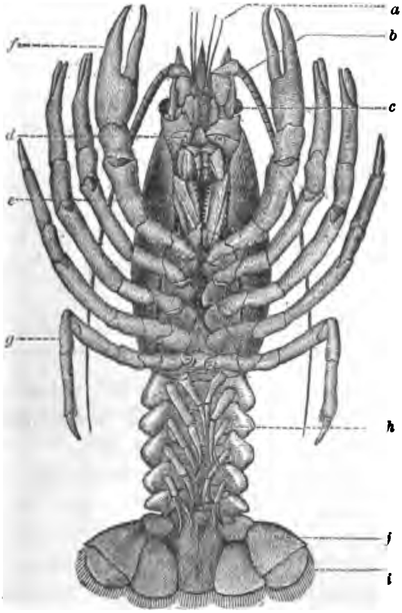

Fig. 471.—Cray-Fish; *a* and *b*, antennæ; *c*, eyes; *d*, organ of hearing; *e*, external feet-jaws; *f*, first pair of thoracic members; *g*, fifth pair of thoracic members; *h*, abdominal false-legs; *i*, tail-fin; *j*, anus.

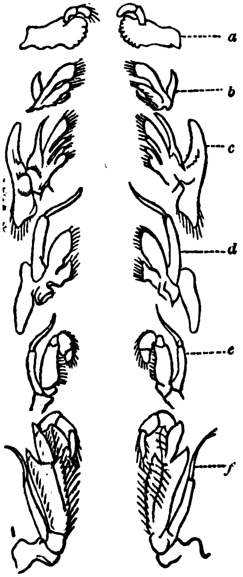

Fig. 472.—Masticatory Apparatus, composed of six pairs of appendages; *a*, mandibles; *b* and *c*, first and second pairs of maxillæ; *d*, *e*, *f*, three pairs of feet-jaws, gradually approaching the form of the ordinary limbs.

Anomoura, in which the condition of the abdomen is intermediate. Each of these sub-orders is divided into families; but it will be sufficient here to notice their principal forms.

785. The Brachyoura may be considered as ranking at the head of the whole Order, in regard to the concentration and high development of their nervous, circulating, respiratory, and secreting systems. They are formed for walking rather

than for swimming; and they are consequently usually found upon the shore, or even quite inland, rather than afloat. The tail or post-abdomen is shorter than the thorax, and possesses no appendages or swimmerets at its extremity; it is folded in a state of rest beneath the thorax, where it is lodged in a hollow

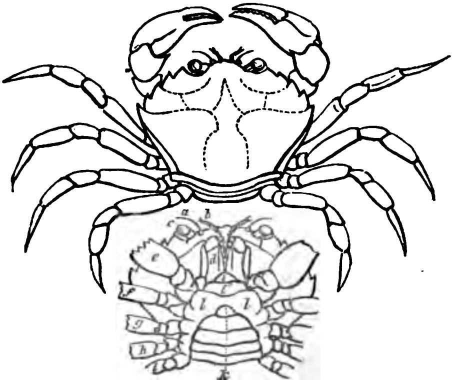

FIG. 473.—CARCINUS MÆNAS, (Common small edible Crab), upper side, and under side of the body with the limbs cut short; *a*, lateral antenna; *b*, intermediate antenna: *c*, eye; *d*, outer foot jaw; *e*, *f*, *g*, *h*, *i*, base of the five pairs of legs; *k*, tail; *l*, sternum.

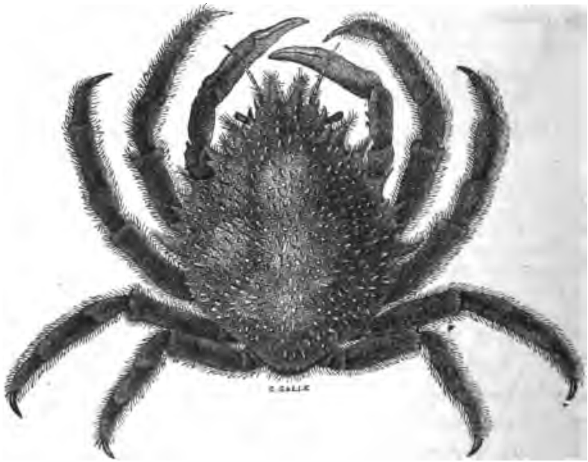

FIG. 474.—MAIA.

fitted to receive it; and in the female it is furnished with four pairs of double filaments, analogous to the sub-abdominal swimming appendages of the long-tailed Decapods, and used for carrying the eggs. The claws, or first pair of legs, are alone furnished with pincers; the ordinary legs having only simple pointed terminations.—In the *Maia* (Fig. 474) and other allied genera, the body has very much the form of that of some Spiders, and the legs are very long; whence these Crabs are commonly termed Sea-Spiders by the fishermen.—The *Cancer pagurus*, or common large edible Crab, belongs to a group distinguished by the very great breadth of the carapace, which, in this species, sometimes amounts to as much as twelve inches; it is much arched at the sides, and each border has nine festoons. This Crab is captured, by sinking pots, baskets, or nets, baited with decaying animal matter, to a considerable depth along the rocky coast. During the summer months it is very abundant, especially where the water is deep; but in winter it is rarely to be found, and it is supposed to burrow in the sand, or to retire to the deeper parts of the ocean. The *Carcinus Mænas*, or small edible Crab, is very active in its habits, running with considerable speed; it is caught, however, in large numbers, but is principally eaten by the lower classes, being less esteemed than the preceding as an article of food; its breadth seldom exceeds three inches. There are several other species of this group, which are used as food in different parts of the world, where they take the place of the preceding.—The *Podophthalma*, which is extremely remarkable for the length of its eye-bearing foot-stalks (Fig. 462), belongs to a group of Crabs distinguished by the flattened form of the last pair of legs, which are used as oars, and enable the animal to swim with facility.

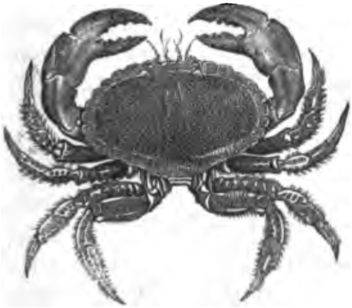

FIG. 475.—CANCER PAGURUS.

786. Of the group of *Brachyourous* Decapods formed to live at a distance from the sea, there are many species; some of them inhabiting fresh water, whilst others form burrows in the ground, even at a distance from water. Of the genus *Thelphusa*, one fresh-water species, a native of the rivers of Southern Europe, was well known to the ancients, who often represented it upon their medals; the Greek monks eat it uncooked, and it is a common article of food in Italy during Lent. Another species, which inhabits India, has been thus noticed by Bishop Heber in his Journal:—"All the grass through the Deccan generally swarms with a small Land-Crab, which burrows in the ground and runs with considerable swiftness, even when encumbered with a bundle of food as big as itself; this food is grass, or the green stalks of rice; and it is amusing to see the Crabs, sitting, as it were, upright, cut their hay with their sharp pincers, and then waddling off with their sheaf to their holes, as quickly as their side-long pace will carry them." They have been found on the table-lands, at an elevation of nearly 4000 feet from the sea; and there is reason to believe that they do not, like the West Indian Land-Crabs, perform an annual migration to the sea, for the purpose of depositing their eggs.—The *Gecarcinus*, or Land-Crab of the Antilles (Fig. 469), is remarkable for its nocturnal and burrowing habits, and for the migrations it executes; when the season arrives for the deposition of the eggs, it moves towards the sea in large companies, taking the most direct line, and seldom permitting any obstacles to interrupt its progress.—Some of the Land-Crabs are remarkable for the inequality in the size of their claws; the larger is used to close up the mouth of the burrows; and it is

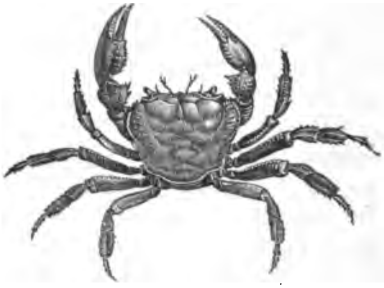

FIG. 476.—THELPHUSA.

sometimes held up in a beckoning attitude, whence these Crabs have acquired the name of Calling-Crabs.—Nearly allied to these, which are all inhabitants of tropical regions, are some small native species, termed Pea-Crabs, which reside, at least during a part of the year, inside various bivalve shells, such as Mussels, &c. The ancients believed that the Pea-Crab lives on the best terms with the inhabitant of the shell in which it is found; and that it not only warns it of danger, but goes abroad to cater for it; this, however, is an absurd fiction.

787. The Decapods of the section Anomoura are intermediate between the Short-tailed Crabs, and the Long-tailed Lobsters and Cray-fish; not having the abdomen reduced to the almost rudimentary state, which it presents in the former; neither having it converted into a powerful organ for swimming, as in the latter (Fig. 477). There is nearly always a pair of appendages attached to its last segment; and these have, in some instances, important uses. This section includes the *Hippa* (Fig. 460) and its allies, constituting the family Hippidæ; and also the family Paguridæ, or *Hermit-Crabs*, which are very peculiar as to both their conformation and their habits. The tail, or post-abdomen, is of large size, but its envelope is little else than a membranous bag, entirely unpossessed of the usual hardness of the Crustaceous integument, and presenting no division into segments. The thorax itself is not very firm; and it is only on the claws, which are of large size, that we find the true calcareous envelope. For the protection of their soft tails, the *Paguridæ* resort to various artificial methods. Many of them seek univalve shells, in which they take up their abodes; attaching themselves to their interior by a sucker, with which the tail is furnished at its extremity, and also holding by the three pairs of appendages, or false legs, which it bears at its hinder portion. When they are feeding or walking, the head and thorax project beyond the mouth of the shell; but when they are alarmed they draw themselves in,

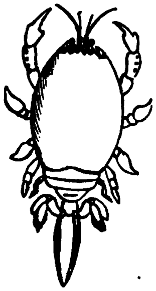
Fig. 477.—Remipes Testudinarius.

closing the mouth with one of the claws, which is much larger than the other, and holding to the interior so firmly, that they will rather be torn asunder than quit their attachment. As they increase in size, they are obliged to change their habitation for a more commodious one; and the way in which they accomplish this is very amusing. They may be not unfrequently observed crawling slowly along the line of empty shells, &c., left by the last wave; and as if unwilling to part with their old domicile till a new one has been obtained, they slip their tails out of the old house into the new one, again betaking themselves to the former, if the latter is not found suitable. In this manner they not unfrequently try a large number of shells, before they find one to their liking. There are several species of various sizes, which are inhabitants of our own shores; they feed, for the most part, upon dead fish, and all kinds of garbage thrown upon the shore. The *Birgus*, an allied genus of tropical regions, has the tail somewhat more protected, but still soft; this does not lodge in shells, but retires to rocks, or hides itself in burrows in the earth. The best-known species, *Birgus latro*, inhabits the Isle of France, and lives upon cocoa-nuts; it burrows at the roots of the trees, and feeds upon the fruit which falls from them; and it is even said to climb the trunk, to obtain a further supply.

788. The Macroura, or long-tailed Decapods, are distinguished not merely by the length of the tail, but by having it terminated by a sort of fin, expanded laterally, and consisting of five pieces (Fig. 478). This is a very powerful instrument for motion in water, serving, by its vertical strokes, to propel the animals through the liquid; and we consequently find the Crustacea of this Section much more frequently swimming in the water than walking on its bottom or on the shore. This Section is a very extensive one, and contains the largest species of the whole class. The *Lobsters*, *Cray-fish*, *Prawns*, *Shrimps*, &c., of which the group is chiefly composed, are sufficiently well known to need no description. We may notice, however, the *Palinurus*, or Spiny Lobster, one of the largest animals in the class; which was known to the Romans under the name of Locusta. This is distinguished by the very large size of its

lateral antennæ; which are beset, like the body, with sharp points. The legs are all single-fingered; not even those of the first pair being furnished with pincers. This animal frequents deep waters, especially off rocky shores; and it only approaches the coast at the return of spring, to deposit its eggs, which are numerous, minute, and of a bright red colour. The common English species not unfrequently weighs 12 or 14 lbs., when

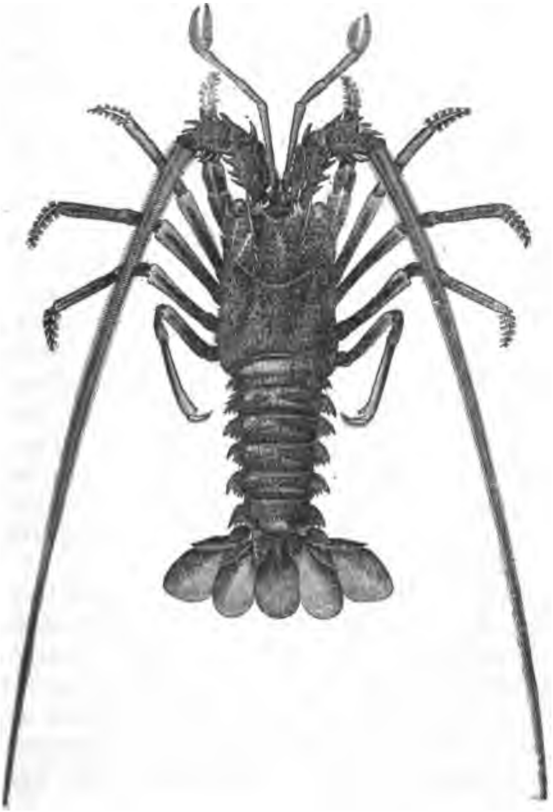

FIG. 478.—PALINURUS.

loaded with eggs.—The *Galathea*, a genus somewhat allied to the preceding, and of which two small species are common on our own coasts, is remarkable on account of the vast numbers in which it sometimes appears; the *Galathea gregaria* having been seen by Sir Joseph Banks, during his voyage round the world, to accumulate in such multitudes, that the surface of the water appeared as if saturated with blood.

ORDER II.—STOMAPODA.

789. THE name of this Order is derived from the mode in which the feet approach the mouth, in many of the animals composing it; not only the foot-jaws, but also part of the thoracic extremities, being directed towards it (Fig. 480). The number of legs is variable; but there are generally from twelve to sixteen,—one or more pairs of the feet-jaws of the Macrourous Decapods being here developed as true legs. The general form of the body bears considerable resemblance to that of the Cray-fish and its allies; the abdomen being much prolonged, the tail-fin much expanded laterally, and the appendages beneath the abdomen being developed and used as fin-feet. There are, however, some considerable differences in their structure; which are quite sufficient to separate the Stomapods as a distinct Order. The branchiæ, instead of being inclosed in a cavity beneath the thorax, are attached to the abdominal appendages, and hang freely in the water (Fig. 468); the heart has more the form and characters of the dorsal vessel of Insects; the integuments have little solidity, and are sometimes membranous and translucent; and the nervous system is arranged in a less concentrated manner.—All the Stomapods are marine; and the largest species are only found in tropical climates. As they are inhabitants of deep waters and the open sea, rather than of the shores, their habits are but little known; but from the conformation of some of the Order, they may be regarded with probability as very voracious.

790. As connecting this Order with the last family of the

preceding, we may first notice the curious genus *Mysis*, or Opossum-Shrimp; which bears, in its general form, so strong a resemblance to the ordinary Shrimps, that it has been usually placed with them. It is distinguished, however, from the true Decapoda, by the external position of its branchiæ; as well as by other characters. In regard to the number of the feet, it holds a very interesting intermediate place between the Decapods and the ordinary Stomapods; for the last pair of feet-jaws is developed into true legs, making their number twelve in all; and the other two pairs have much more the form of ordinary legs, than in the Decapods. Each of the legs has a lateral appendage, which is so much developed as to appear like a second limb; and thus, reckoning-in the feet-jaws, which also possess similar appendages, we may say that the Mysis has no fewer than 32 legs. The common name of this curious little animal is derived from the peculiar conformation, which enables it to afford a special protection to the eggs. The female has a large concave scale, attached to the inner division of each of the posterior legs; and these, overlapping one another, form a pouch, which is capable of being considerably distended. Into this pouch the eggs are received, when they quit the ovarium; and here they continue until the young are so nearly developed, that they present a very close resemblance to the parent. The parent then opens the valves of the pouch, and sets free the whole brood at once into the surrounding element; and these usually seem to remain associated with the community, from which they sprang. Although sparingly distributed in the seas of Europe, these little animals inhabit some parts of the Arctic ocean in amazing numbers; constituting the principal food of the prodigious shoals of Salmon, which resort thither in the months of July and August, and upon which the inhabitants of Boothia depend in great degree for their winter store of provisions; and

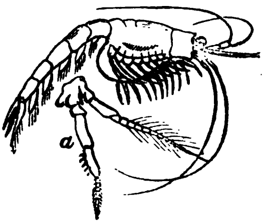

FIG. 479.—MYSIS VULGARIS, about twice the natural length: *a*, one of the bifid legs.

serving also as one of the chief articles, on which the Whalebone Whale is supported.

791. The *Squilla*, which is sometimes termed " Sea Mantis," from the resemblance of its powerful claws to those of that Insect (§ 664), may be regarded as the type of the Order. Its carapace is small, and only covers the anterior half of the thorax; —the posterior being formed of rings like those of the abdomen.

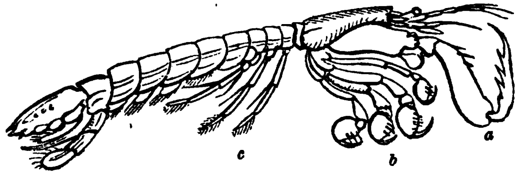

FIG. 480.—SQUILLA MANTIS.

The members which, in their position, correspond with the external feet-jaws of Decapods (Fig. 480, *a*), are here developed into enormous claws, terminating in a sharp hook; in the typical species, *Squilla mantis*, the last joint or finger is furnished with six sharp projecting spines; and the preceding joint, or hand, is furnished with three sharp spines, and is hollowed at its edge into a groove, into which the finger shuts, in such a manner as to render this claw a most efficient instrument of prehension. The other foot-jaws, and the three first pairs of thoracic members (*b*), share in this conformation; being furnished with a sharp moveable finger, and a hand armed with spines, against which the finger closes; and these are directed towards the mouth, in such a manner as to hold the prey against it, in the most efficient manner. The three posterior pairs of legs, which are attached to the annulated (or ringed) portion of the thorax (*c*), are furnished with a brush instead of a hook at their extremities, and more resemble the abdominal swimming legs. The tail is expanded into a broad fin. Thus we see that the locomotive apparatus of this animal is partly adapted for prehension, and partly for natation (or swimming), and not at all for walking. This species is probably the largest of the Order; its length being about seven inches. It is common in the Mediterranean.

792. To this Order also belongs a very curious genus, the *Phyllosoma*, or Glass-Crab. Its scientific name, which means *leaf-bodied*, as well as its common designation, refer to the remarkable peculiarity of structure by which it is distinguished; the whole body being flattened like a leaf, and almost as transparent as glass. It is composed of a large oval plate, which represents the head, and bears the two eyes, mounted on long footstalks, at its anterior extremity; of a second plate, in part covered by the preceding, and giving insertion to the thoracic legs; and of an abdomen which is always short, and in some species undeveloped. The legs, six in number, are very long and slender; they are bifid or divided into two, like those of the Mysis; and are adapted for swimming only. These curious creatures are inhabitants of the tropical parts of the Atlantic and Eastern Oceans.

793. It is scarcely possible to avoid being struck by the analogy presented by this Order, to the Orthoptera among Insects. The resemblance of the Squilla to the Mantis has already been noticed; and the correspondence of the Phyllosoma to the leaf-like species of the same order (§ 653), is scarcely less remarkable. We may also point out the many resemblances between the Decapod Crustacea, and the Coleopterous Insects. They occupy a corresponding position, in being at the head of the *mandibulate* series of their respective classes; they are both also pre-eminent in regard to the hardness of their integuments; and in both there is an adaptation of the extremities for walking, rather than for swimming or flying—which are actions analogous to each other (ANIM. PHYSIOL., § 663).

SECTION B.—EDRIOPHTHALMA.

ORDER III.—AMPHIPODA.

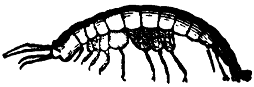

FIG. 481.—GAMMARUS PULEX.

794. Passing on to the group of EDRIOPHTHALMA,—which is distinguished by the absence of peduncles supporting the eyes, and by the union of the respiratory organs with the locomotive members,—we have to first notice the Order AMPHIPODA, in which the abdomen is well developed, but the respiratory organs are connected with the thoracic limbs only. These organs consist of membranous vesicles, attached to the base of the legs, of which some traces present themselves in the preceding Order; the continual renewal of the water in contact with them is accomplished by the constant movements of the first three pairs of abdominal pro-legs. The thoracic legs are fourteen in number, consisting of the ten which are characteristic of the Decapods, with the addition of two pairs of feet-jaws,—only one pair of these last organs being here left in its original form. The legs are partly directed forwards, and partly backwards, from which the name of the Order is derived. The abdomen is much developed, and is composed of seven segments,—the last, however, being a mere rudiment; the appendages of the three preceding divisions are often united into a sort of bundle, constituting an organ which is of great service in leaping. These Crustacea are all of small size; but they frequently present themselves in very large numbers. Some of them are inhabitants of the sea and shores, whilst others are abundant in our streams. The greater number of them are very agile leapers.

795. The common *Talitrus locusta,* or Sand-hopper (Fig. 456),

is a very characteristic example of this Order. It is extremely abundant on our shores; and may often be seen in vast numbers on the sands, especially when the sun is shining upon them and the tide is retreating. The whole surface of the sand, or rather the air for a few inches above it, appears as if alive with them; for they are incessantly leaping to an elevation, which is, for their minute size, very considerable, as if they were in the height of enjoyment. They burrow in the sand; and seldom enter the water. Their food probably consists of the minuter animals, and of the decomposing animal and vegetable remains, which are left in the sand by the sea. The *Gammarus pulex* (Fig. 481), which is nearly allied to the preceding in structure and in its leaping powers, is an inhabitant of fresh water brooks; being especially abundant in those, in which there is an accumulation of decaying vegetable matter. The *Coryphium* is remarkable for its very long antennæ, and for its predaceous habits. It is very abundant on the coast of La Rochelle, where it forms extensive burrows in the sand,—only making its appearance, however, at the beginning of May. It keeps up a continual war with the Annelida, which inhabit the same neighbourhood; and also attacks Mollusca and even Fishes, as well as dead animal matter. Scarcely anything is more curious, than to observe these creatures at the rising of the tide assembled in myriads, moving about in all directions, beating the mud with their arm-like antennæ, and mixing it with water in order to discover their prey. If they meet with Annelids even ten or twenty times their size, they unite together to attack and devour them; and the carnage does not cease, until the whole of the mud has been turned over and examined. It is said that they sever the *byssus*, by which the Mussels are fixed (Fig. 591); so as to cause them to fall, and thus to enable them to be more readily attacked. They are in their turn devoured by Fishes and by many Shore-Birds. The Crustacea

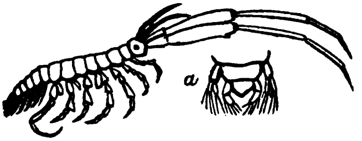

FIG. 482.—CORYPHIUM LONGICORNE; *a*, terminal segment of the tail.

of a portion of this Order are parasitic in their habits; attaching themselves to the bodies of Fishes; and having the mouth more adapted for suction.

ORDER IV.—LÆMODIPODA.

796. The Crustacea of this Order resemble the preceding in the conformation of the respiratory organs; but differ from all the other Edriophthalma, in the want of development of the abdomen. The number of legs varies considerably in the different species. The body is composed (with the head) of eight or nine segments, of which seven may be furnished with members; but not unfrequently some of the appendages are undeveloped. This Order is divided into two Sections, according to the form of the body; the *Filiformia*, having the body long and thread-like, and the legs also long and slender (Fig. 483); whilst in the *Ovalia*, the body is shorter and broader, and the legs shorter and stouter (Fig. 484). Of the former group, the *Caprella phasma* is a characteristic example; it is found among marine plants, creeping along in the same manner as the Geometer, or Looper-Caterpillars (§ 700), often bending itself back with great rapidity, and applying its antennæ to various parts of the body. It has five pairs of legs, of which the second is the largest; these are not disposed, however, in a regular, but in an interrupted series, the second and third segments of the thorax having only the respiratory vesicles. In an allied genus, there are also ten legs, disposed in a continuous series; and in another, all the fourteen are developed.

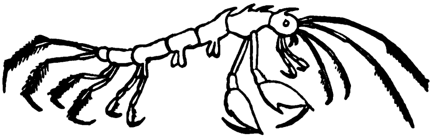
FIG. 483.—CAPRELLA PHASMA.

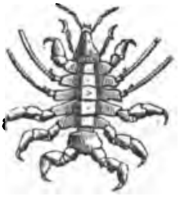
FIG. 484.—CYAMUS BALÆNARUM.

The *Cyamus* and its allies, belonging to the second division of the Order, appear to be mostly parasitic in their habits. The Cyamus, commonly termed the Whale-Louse, attaches itself, by means of its strong claws, to the surface of the body of the Whale; which is sometimes so completely covered by these parasites, that the individuals thus infested may be easily recognised at a considerable distance by their white colour. When the parasites are removed, the skin of the Whale is found to be deprived of its epidermis.

ORDER V.—ISOPODA.

797. These Crustacea bear a general resemblance to the Amphipoda; but their bodies are flattened horizontally, instead of being compressed vertically, and the abdomen is not terminated either by appendages adapted for leaping, nor by an expanded fin for swimming, as in that group. The thorax nearly always consists of seven segments, and is furnished with seven pairs of appendages adapted for walking (Fig. 456); but the respiratory organs are not attached to them, but are developed as expansions of the extremities of the pro-legs, which are attached to the abdominal segments. These organs, which have usually an oval form and a membranous texture, are sometimes suspended freely beneath the abdomen; but they are occasionally covered in by little scales, which fold over and protect them. The females usually have large plates attached to the base of the thoracic legs, which form, by their meeting, a pouch in which the eggs and young are matured; others have a membranous bag in this situation: The newly-hatched young have only six thoracic segments and six pairs of legs,—acquiring an additional segment and pair of legs at the time of their first moult.

798. Of this Order, the principal part is aquatic; but one group is terrestrial. Many of the former are parasitic upon other animals,—very frequently upon larger Crustacea; this is the case with the *Bopyrus*, which is parasitic upon the common Prawn, affixing itself beneath the carapace, upon the branchiæ,

and producing an evident swelling externally. Between eight and nine hundred young ones have been observed beneath the body of a single female ; and the parent has the instinct to set them free in situations frequented by the Prawns.—Of those marine Isopods which are not parasitic, the most worthy of notice is the *Limnoria terebrans ;* which, although not more than a sixth of an inch in length, is, through its boring habits, and its powers of multiplication, exceedingly destructive. It pierces timber in different directions with astonishing rapidity, apparently for the purpose of feeding upon it, as in its stomach are found minute particles of the wood. It is found in different parts of the British Ocean, attacking wooden piles, immersed in water, in our dock-yards, bridges, flood-gates, chain-piers, &c. ; and perforating them in the most alarming manner.

799. It is in the terrestrial species, that we find the most remarkable provision for the inclosure of the respiratory organs ; these being completely folded over, by plates developed from the abdominal members ; and the anterior plates being perforated with a row of small holes, through which the air gains access to the gills within. Like the Land Crabs, these terrestrial Isopods (of which the common *Wood-louse* is a very familiar example), for the most part frequent damp situations ; inhabiting dark and concealed places, such as cellars, caves, holes in walls, the under-side of stones, &c. They feed upon decaying animal and vegetable matter, and come forth from their retreat in damp weather. They crawl slowly, except when alarmed ; and they have the power of rolling themselves into a ball, so as to expose on the outside nothing but the plates of the back, and to conceal the appendages of the underside of the body.

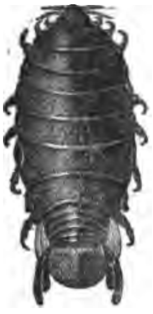

FIG. 485.—ANILOCRA.

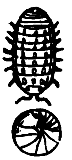

FIG. 486.—ARMADILLO PUSTULATUS.

800. The order Isopoda is probably the situation, in which we are to place the remarkable fossils known under the name of *Trilobites*, from the three lobes into which the body is divided lengthways (Fig. 487). These are found in the very earliest of the formations that contain fossils at all; and they appear to have ceased to exist, before the creation of Mammalia. They resemble the Isopoda in the equality of their segments, as well as in the tri-lobed division of the body, which is presented by some of the recent species of that order; and also in their tendency to roll themselves into a ball (Fig. 488). Their exact situation, however, cannot be known, until some information has been gained in regard to their extremities, of which no remains have yet been discovered. It is probable that these were very short; in which respect they would correspond with those of certain parasitic Isopods; but they may have been soft and membranous, and formed for swimming, like those of the Phyllopoda. They bear no inconsiderable resemblance externally to the *Chiton* among Mollusca (Fig. 584); and could probably, like them, draw the border of the shell completely down to the surface on which they were adherent. Their Articulated character, however, is fully evidenced by the nature of their eyes, which have the compound structure peculiar to that Sub-Kingdom. This has been so perfectly preserved in many specimens, that the facets may be counted with the aid of a magnifying-glass; and as many as four hundred have been found to exist in a single specimen.

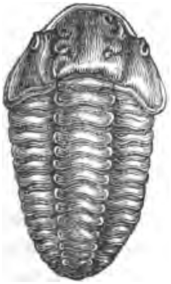

FIG. 487.—CALYMENE BLUMENBACHII.

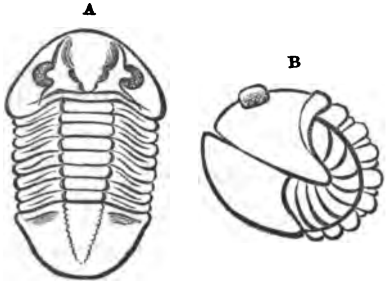

FIG. 488.—A, ASAPHUS EXPANSUS. B, THE SAME ROLLED UP.

SECTION C.—BRANCHIOPODA.

ORDER VI.—PHYLLOPODA.

801. We are now arrived at the third Section of the class,—that of BRANCHIOPODA; in which the union between the legs and respiratory organs, which we have seen to be gradually taking place in the preceding Orders, becomes more complete,—there being now no distinct gills, and the anterior legs being converted into respiratory organs, by an expansion of their surface. Hence the name of the group; which means "gill-footed." In the greater part of this and the succeeding groups, the body is inclosed in a sort of horny shell; which sometimes appears composed of but a single piece, and in other instances is formed like the shell of a bivalve Mollusk:—hence they are commonly known as *Entomostracous* Crustacea (this term meaning, inclosed in a shell). The eyes are generally placed near each other; and are sometimes so close, as to run together (so to speak) into one mass. The foot-jaws are all converted into true legs, being, like them, adapted for swimming; and even the antennæ sometimes become locomotive organs. The number of legs varies greatly; reaching in some species to above a hundred; but being commonly much less. All these animals are aquatic, and most of them inhabit fresh water. They are for the most part extremely active in their habits; and are all of small size, some of them being even of microscopic minuteness. This active locomotion is doubtless in part connected with the act of respiration, and serves to produce a constant interchange in the water in contact with the surface of the body, and especially

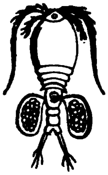

FIG. 489.—CYCLOPS VULGARIS, magnified.

with the branchial expansions of the legs. Even when the animals are at rest, these last organs are seen to be in rapid motion. The eggs are arranged in a mass in a cavity beneath the back of the shell, or are inclosed in a common envelope, and carried in one or two bunches or masses at the base of the tail (Fig. 489).

802. The Order PHYLLOPODA includes those Branchiopoda, whose body, sometimes naked or shell-less, and sometimes inclosed in a shield-like carapace or in a bivalve shell, is divided into a great number of segments, nearly all of which are furnished with leaf-like appendages, or gill-feet. They vary considerably in their conformation ; some of them being provided with a certain number of simple swimming feet, placed behind the gill-feet ; but of the latter there are always at least eight pairs, and sometimes their number amounts to sixty pairs. The first division of the order includes those, which have the body protected by a horny shell. This is the case with the *Limnadia* (Fig. 490), which has a bivalve shell, and bears a considerable resemblance to the Daphnia (§ 804), except in the form and number of the feet ; and in the *Apus* (Fig. 491), which has a simple shield-like shell, and in which the feet are very numerous, but all except the anterior ones are extremely small. These last are extremely remarkable for the power which their eggs possess, of retaining their vitality for several years, when the waters in which they are deposited have been dried up. They inhabit lakes, pools, and ditches, and are often found in vast numbers, especially in the spring and beginning of the summer. They are sometimes raised into the air by whirlwinds, and scattered again

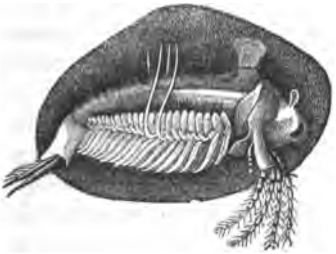

FIG. 490.—LIMNADIA.

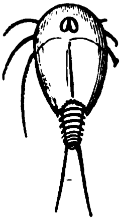

FIG. 491.—APUS MONTAGUI.

like rain. Their eggs are of a red colour, and fall to the bottom of the water, when set free from the egg-cases which the parent bears near its tail. When first hatched, the young differ considerably from their parents, having but one eye, four legs, no tail, and the shell covering only the front half of the body. These little Crustacea are said to feed upon young Tadpoles. They swim well on the back, and burrow in the sand, elevating their tails in the water.

803. In the species included in the second division of the Order, there is neither bivalve shell, nor any trace of a shield-like carapace; but the body is entirely soft. It is usually much prolonged, and composed of a large number of segments; but the branchial appendages or gill-feet do not exceed eleven pairs. To this group belongs the curious *Artemia salina*, or Brine-shrimp; a small Crustacean, about half an inch in length, commonly found in the salt-pans at Lymington, when the evaporation of the water is considerably advanced. The accompanying figures represent the progressive stages of its development. "Nature having constructed it with members solely adapted for swimming, it seems to be in perpetual quest of prey, gliding with an almost even motion through the water, and moving with equal indifference on the back, belly, and sides; the shape of the animal, the undulating movements of its fins, and the glossy appearance of its coat, render it an object of a very interesting description."—Nearly allied to this is the *Branchipus*; of which the several species are found, often in great numbers, in small pools, especially after heavy rain; sometimes even in those which are left on the uneven surfaces of stones,—the eggs, which are inclosed in a strong shell, seeming

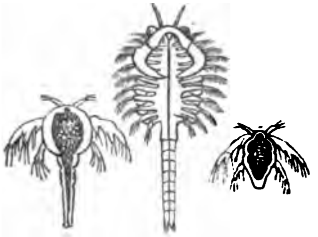
FIG. 492.—ARTEMIA SALINA, in different stages.

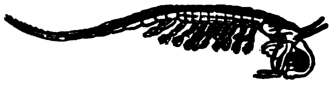
FIG. 493.—BRANCHIPUS STAGNALIS.

to have been transported by the wind. The *Branchipi* generally swim on their backs; and their short lamellar feet, which are unfit for walking, are then kept in an undulatory motion, that sends forward a current of water, along a channel hollowed in the lower side of the body, to the mouth, and thus supplies the animal with food. At other times, they swim more forcibly, by alternate lateral strokes of the tail upon the water.

ORDER VII.—CLADOCERA.

804. The Order CLADOCERA consists of those minute Crustacea answering to the foregoing description, which have the body inclosed in a bivalve shell. These belong, for the most part, to the genus *Daphnia;* of which the common species, *Daphnia pulex* (which has also received the name of *Monoculus* from its single eye), is commonly termed the Arborescent Water-Flea, from its power of leaping, and from the branching form of its antennæ, which serve as oars. It is very abundant in many ponds and ditches, coming to the surface in the mornings and evenings, and in cloudy weather; but seeking the depths of the water during the heat of the day. It swims by taking short springs, and feeds on minute particles of vegetable substances, not however rejecting animal matter when offered. There are several curious points, relative to the propagation of these little animals, which are worthy of notice. After the eggs leave the ovaries, they remain in a large cavity between the body and the shell; here they usually attain their complete development,—the young coming forth into the world, in a form very nearly resembling that of the parent. From the transparency both of the eggs and of their containing envelope, the whole process of development may be distinctly seen. At first the eggs are quite round, and seem as if made up of a multitude of minute globules. The shape then alters a little, becoming oval; and these globules augment in number; but as yet no trace of any body is perceptible. A little afterwards, we see a black spot in the centre, which is the eye, and which is the first organ visible.

The other organs then begin to show themselves; but it is not until near the end of the fourth day, that any motion is perceptible. They come forth into the world, at the end of the fifth day, with the tail curved up within the shell; and very shortly after birth, this tail may be seen to spring forth with a sudden jerk, and to assume its natural position. In a short time afterwards, the animal acquires the perfect form, and it speedily increases in size,—throwing off its envelope, and acquiring a new one, at short intervals. In summer these moultings are frequently seen to be performed every two days; but in colder weather, several days elapse between them. They do not cease with the full growth of the animal, but continue during its whole life. The purpose of this may be, to prevent the animal being injured by the tendency of its shell to become overgrown with parasitic Animalcules and Confervæ; for weak and sickly individuals may be frequently seen so covered with these growths, that their motion and life are soon arrested, the animals apparently not having strength enough to throw off their envelope.

805. After the third or fourth moulting, the young Daphnia begins to deposit its eggs in the cavity of its back; these may be frequently seen there, as early as the tenth day of its separate existence. Soon after the young are born, another moulting takes place; and the egg-coverings, which have been left in the cavity, are thrown off with the shell. In a very short time afterwards, another brood of eggs is seen in the cavity; these are soon hatched, and another moult takes place; and these processes continue to take place through the whole season, until the weather becomes severe. All the *Daphniæ* then seem to be destroyed; none having their existence prolonged through the winter. There is, however, a very curious provision for perpetuating the race. At particular seasons, the *Daphniæ* may be found with a dark opaque substance on the back of the shell. This has been termed the *ephippium*, from its resemblance to a saddle. When examined by the microscope, it is seen to be of a dense texture, and to be composed of a mass of hexagonal cells; and to contain two oval bodies, which are capsules opening like a bivalve shell, each inclosing an ovum covered with a horny

envelope. This is first seen after the 3rd moulting; after the 4th it passes into the open space in the back; and at the 5th it is thrown off with the shell, and remains floating on the surface of the water, until the temperature rises sufficiently to hatch the eggs. The ephippial eggs which are deposited in the summer are probably developed during the same season; but those which are laid in the autumn remain undeveloped during the winter, being protected by their peculiar envelopes; and it is by the action of the returning warmth of spring upon them, that the new generation of Daphniæ is produced in the next year. They may be at any time hatched, however, by artificial warmth. "These two species of eggs," says an attentive observer of the processes now described, "produced by the same being, offer a very singular example in the history of animals, and show with what wisdom Nature provides for the preservation of even her smallest creatures."

806. The *Polyphemus* has, like the Daphnia, oar-like antennæ, divided into two branches. It is remarkable for the large size of its head, which is almost entirely occupied by a single enormous eye (Fig. 494.) It swims on its back or sides, giving to its antennæ and legs quick and repeated motions, and executing with the greatest ease all kinds of evolutions.

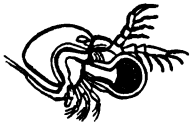

FIG. 494.—POLYPHEMUS STAGNORUM, magnified.

SECTION D.—ENTOMOSTRACA.

ORDER VIII.—OSTRAPODA.

807. We are now arrived at the last group of Masticatory Crustaceans; in which we lose all trace of organs peculiarly adapted for respiration,—the feet not being modified for this purpose, as in the last Section, but being expressly formed for swimming, each member being terminated by two oars composed

of two or more joints. There is considerable resemblance, except in the conformation of the mouth, between some of these and the *Suctorial* Crustacea hereafter to be described. It is to this group, that the term *Entomostrasous* has been restricted by later Naturalists; but it is commonly applied to the minute Branchiopodous Crustacean just described, and even to the *Limuli* (§ 816), as well as to these—all agreeing in the inclosure of the body in a single or bivalve shell.

808. In the Order OSTRAPODA, the body does not exhibit a division into distinct rings, and is altogether inclosed between the two valves of a bivalve shell. This shell is furnished with a hinge, like that of a bivalve Mollusk; and can be closed in such a manner as to envelop the animal completely; but the valves are in general sufficiently wide apart, to allow the extremities of the antennæ and feet to pass out between them. There are two pairs of antennæ; of which the first (*a*, Fig. 495) is slender, whilst the second (*b*) is large, directed downwards, and adapted for swimming. The mouth is situated near the middle of the inferior surface of the body; it is furnished, besides an upper and lower lip and a pair of mandibles, with two pairs of maxillæ; of which the posterior carries a large flapper-like appendage, that is probably to be regarded as a branchial organ. The true thoracic feet are only four or six in number. The body terminates in a bifid tail; and the eggs are lodged, as in the Daphniæ (to which these animals bear a strong general resemblance), in a cavity between the back and the shell. The principal genus of this Order is the *Cypris*, which, like the Daphnia and the Branchippus, is an inhabitant of pools and streams; and strongly resembles the former of these, in regard to its moultings and the deposition of its eggs. The young are not born alive, however; for the mass of eggs, including about twenty-four, is attached by the female to water-plants, with the aid of a glutinous secretion,—an operation which lasts about twelve hours. There are but two pairs of legs in this genus, of which the posterior does not make its appearance outside the shell; being bent upwards

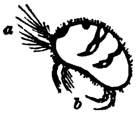

FIG. 495.—CYPRIS VIDUA, magnified.

to give support to the ovaries. The food of these little animals consists of dead (but not putrid) animal matter, confervæ, &c.; but they will not attack living animals that are well and strong, although they are often seen to attack worms, &c., when wounded and weak, and even to prey on one another. When the ponds and ditches in which they live dry up in summer, they bury themselves in the mud, and thus preserve their lives as long as the mud retains any moisture,—becoming as active as ever when the rain falls, and again overflows their habitations. After long-continued droughts, however, when the mud becomes very dry and hard, they perish; but the race is then kept up by the eggs, which are capable of resisting this influence. These little creatures are very lively; being almost constantly seen in motion, either swimming by the united action of their antennæ or anterior feet, or walking upon plants and other solid bodies floating in the water. When alarmed, they draw their antennæ and legs within the shell, and close its valves so firmly, that there is no possibility of opening them. An allied genus, *Cytherina*, distinguished by the possession of three pairs of legs, is an inhabitant of salt water.

809. There is abundant evidence of the former existence of the minute Crustacea of this group, to an enormous extent; and their size was much greater. The largest existing species of Cypris does not exceed one-sixteenth of a line in length. But in certain strata of the Secondary and Tertiary formations, which appear to have been deposited by fresh water, we find layers, sometimes of great extent and thickness, which are almost entirely composed of the fossilized shells of Cyprides, many of them exceeding a line in length; and in the Chalk, which was a marine deposit, the remains of bivalve Crustacean shells, probably belonging to the genus Cytherina, are frequently to be found in great abundance.

ORDER IX.—COPEPODA.

810. The Entomostraca of this Order bear a strong resemblance in the general form of their bodies to the Edriophthalma; they have no carapace, nor bivalve shell, like that of the last Order; and their envelope is of membranous or soft consistence. The head is large, and distinct from the thorax; and the body is distinctly divided into several segments, of which the thorax presents from three to five, and the abdomen two or more. The number of legs is always at least eight or ten; and the abdomen is terminated by a bifid tail adapted for swimming. The first pair of antennæ is long, slender, and many-jointed; those of the second pair are sometimes wanting, and sometimes developed into swimming-legs. The mouth is furnished, besides the mandibles and maxillæ, with two or three pairs of feet-jaws; of which the posterior are usually very large, and furnished with a set of feathery bristles, which almost cover the remainder of the buccal apparatus. In one division of the Order, we find the two eyes quite distinct; in the other they form but a single mass on the median line. The eggs are contained, when they quit the ovarium, in two capsules borne at the base of the tail (Fig. 489); and the young, when they first emerge from them, present a form differing greatly from that of the parent, which is only attained after several moults (Figs. 496, 497). The *Cyclops* is a very common genus of this Order; belonging, as its name implies, to the single-eyed division of it. This genus contains numerous species; of which some belong to fresh water, whilst others are

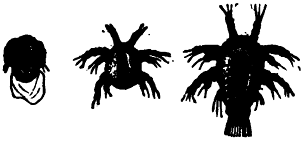
FIG. 496.—LARVA OF THE CYCLOPS.

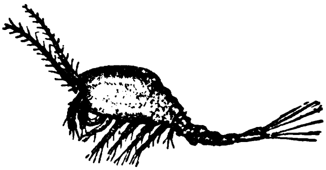
FIG. 497.—CYCLOPS.

marine. The fresh-water species abound in the muddiest and most stagnant pools, and often too in the clearest springs; the ordinary water with which London is supplied frequently contains great numbers of them. The marine species are to be found, often in immense abundance, in small pools on the sea-shore, within high-water mark, living among the sea-weeds and corallines; and others inhabit the open ocean, where, by the luminous properties they possess, they assist in producing its phosphorescence. Their vast numbers are the less surprising, when the extraordinary rapidity of their multiplication is known. It has been calculated by Jurine, who attentively observed their habits, that from one female, 4,442 *millions* of young might be produced in a year. The time occupied in the transformations and development of the young, varies according to the season; and this variation appears to depend, according to the experiments of Mr. Baird,* not only on temperature, but also on the degree of *light*, the metamorphosis being retarded by darkness, as in the Batrachia (§ 483). The Cyclops is carnivorous, feeding upon Animalcules that are brought to the mouth by the action of the feet-jaws, which create a whirlpool in the surrounding water; and in this manner they even devour their own young. In their turn they fall victims to the larvæ of aquatic Insects, the Water-spiders, and other aquatic animals, which thus restrain their multiplication within due bounds. Owing, probably, to the softness of their envelopes, they do not resist drought as well as many other Entomostraca; but they seem capable of resisting almost any degree of cold, and they have been immersed for some time in spirit of wine, without losing their vitality.

811. All these minute Entomostraca furnish very interesting objects for Microscopic examination; and the study of their development and habits will abundantly repay the most diligent observation. Except during the winter, there is probably not a pool of water in this country, that does not contain some species of them.

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* "Magazine of Zoology and Botany," Vol. I., p. 316. A large proportion of the facts here stated respecting these and other Entomostraca, are derived from Mr. Baird's highly interesting and valuable papers in that journal.

812. We next pass to the Sub-Class of *Suctorial* Crustacea, in which the mouth, instead of being furnished with mandibles and maxillæ adapted for the division of solid aliment, is prolonged into a beak, and can only receive liquid substances. Still among the Crustacea, as in Insects, the parts which compose the Mandibulate mouth of the preceding Orders, may be recognised in the Haustellate or Suctorial mouth of those we have now to consider. The proboscis is formed by a prolongation of the upper and lower lip; and it is generally accompanied by a pair of long appendages, which evidently correspond with the mandibles of the preceding Orders, and which serve to make the punctures into which the proboscis is inserted. Other appendages, found at its base, are the representatives of the maxillæ and feet-jaws of the Mandibulate Orders; and these are frequently developed as hooks, by which the animal attaches itself to its prey. Many of the Suctorial Crustacea bear a strong resemblance in their general form to the Cyclops and other Copepoda. The body is usually divided, at its anterior part at least, into distinct segments; and there are generally four pairs of legs, each furnished at its extremity with two oar-like expansions. The resemblance is often strongest in the early stages of development;—the young *Lernæa*, for example (Fig. 502), being scarcely distinguishable from the young *Cyclops* (Fig. 496). But in their advance towards maturity, the Suctorial Crustacea frequently undergo the most extraordinary changes; so that, if we were to attend to their adult forms alone, we should be tempted to exclude them from the class altogether,—in so small a degree do they present its distinguishing characters. This group is divisible into three Orders; of which the first two are parasitic, and the last free.

X. SIPHONOSTOMA. In this Order, the mouth is armed with styliform mandibles; the thorax is composed of several distinct joints, and bears three or four pairs of swimming-feet; and the feet-jaws are well developed.

XI. LERNÆIDA. The mouth in this Order, as in the preceding, is armed with piercing mandibles; but the thorax exhibits no division into segments; and both the feet-jaws and the true legs are undeveloped.

XII. Araneiformes. This very curious group, which was formerly ranked among the Arachnida, has the feet adapted for walking, and well developed; but the mouth is unpossessed of distinct mandibles.

Order X.—SIPHONOSTOMA.

813. The Crustacea of this Order are all parasitic upon Fishes, aquatic Batrachia, &c.; and many of them are known under the name of Fish-lice. Their general characters may be understood from those of the two genera *Argulus* and *Caligus*, which will be briefly described. The *Argulus* has its body covered with an oval shield, which does not extend, however, over the posterior part of the abdomen. There are four pairs of legs, somewhat resembling those of the Branchiopoda, and adapted for swimming. The tail also is a kind of swimmeret. On each side of the beak or proboscis, there is a large short cylindrical appendage, terminated by a curious sucking-disc; and there is also a pair of larger jointed members, terminated by prehensile hooks. These two pairs of organs, enabling the animal to attach itself firmly to that on which it lives, are probably the representatives of the feet-jaws. The eggs of the Argulus are deposited upon floating bodies, like those of the Cyclops; and the young, when they first come forth, bear a strong resemblance to those of that genus. Their swimming organs consist of the oar-like antennæ and feet-jaws; the true swimming legs, and the suckers and hooks on the feet-jaws of the adult, not making their appearance until after several moultings. These Crustaceans may be regarded as in several respects intermediate between those of the preceding Order, and the true Suctorial Crustacea; for they have, even in the adult state, much more locomotive power than the generality of the latter; and are not unfrequently met with swimming freely in the water.

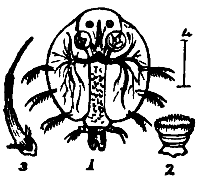

Fig. 498.—Argulus Foliaceus. 1, the animal magnified; 2, one of the large anterior sucking-feet, 3, the siphon; 4, natural length.

814. The *Caligus* (Fig. 499) is much more strange in its form

Its body is composed of two principal portions; the anterior one covered by the oval shield or carapace (Fig. 500, *a*); the posterior, forming the termination of the thorax and the rudimentary abdomen, is divided into rings. The first pair of antennæ is reduced to the condition of small flattened plates, in some species bearing a sucker. The antennæ of the second pair (*b*) also are short, and composed of only two joints. At *c* is seen a sucker, formed by the labrum, and inclosing the mandibles. The maxillæ (*d*, *e*) are represented by two pairs of rudimentary appendages, situated at the sides of the sucker, one of them terminated by horny claws directed backwards. The feet-jaws (*f*, *g*, *h*), to the number of three pairs, are instruments of prehension, by which the animal attaches itself; and behind the last pair of these, there is a forked appendage on the central line (*i*), which probably assists in the same object. There are four pairs of thoracic legs; of which the first three (*j*, *k*, *l*), formed for swimming, are situated beneath the carapace; whilst the last (*m*), which comes forth behind it, is rather adapted for walking. The abdomen forms but a single segment (*p*); and is furnished with a pair of small fin-like appendages (*q*). One of the most curious parts in the structure of this animal, is the pair of long tubes (*r*), which are attached to the sides of the abdomen of the female; these appear to be receptacles for eggs, and to be analogous to the capsules of the Cyclops, &c. (Fig. 489).

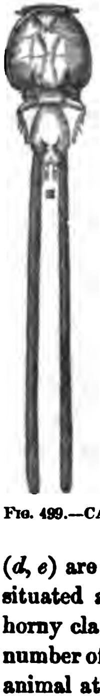

FIG. 499.—CALIGUS.

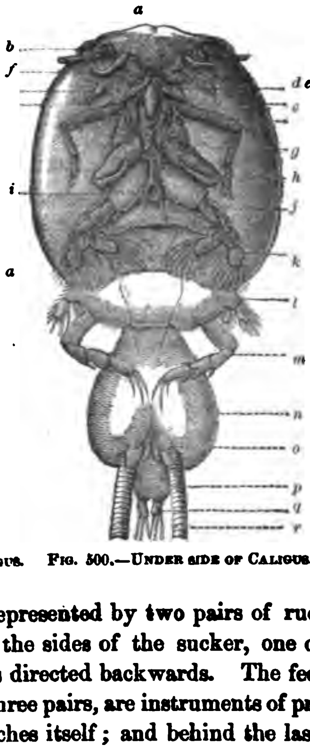

FIG. 500.—UNDER SIDE OF CALIGUS.

ORDER XI.—LERNÆIDA.

815. The animals of this Order depart so widely from the ordinary form of the Crustacea, that, until their early state was known, they were ranked among the lower Articulata. In their adult state, there is an almost complete absence of members or appendages; and those which remain are destitute of joints, being merely fleshy lobes serving to attach the animal to the surface of that on which it lives. They all bear a more or less close resemblance to the *Lernœa*, an animal which is not unfrequently found on the eyes and gills of Fish. The form of the adult is displayed in Fig. 501; which shows its long suctorial trunk or proboscis (*a*); its short thorax (*b*), bearing the pair of legs (*c*), by which the animal is attached; its large abdomen (*d*), and its two egg-capsules (*e*). The legs are united to each other at their extremities; and bear a kind of sucker (*f*), which is applied to the surface attacked by the animal, and assists in retaining it there. The whole anterior part of the body, however, is usually buried in the substance of the part, from the juices of which the Lernæa derives its nutriment.—However dissimilar the form and characters of this creature appear, to those of even the preceding group, yet its connection with them is made evident in two ways. In the first place, there are numerous parasitic species, which depart less from the ordinary type; forming a gradual transition from the Suctorial Crustacea of the last order, to the highly-aberrant form presented by the Lernæa; so that, if the latter is excluded, it would be difficult to say where the line is to be drawn. And again, the early forms of the Lernæa (Fig. 502) so strongly resemble those of the Cyclops and other

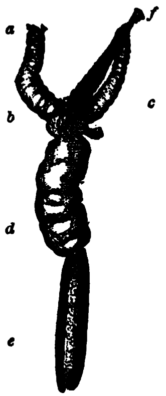

FIG. 501.—LERNÆA.

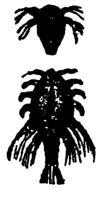

FIG. 502.—LARVA OF THE LERNÆA.

Entomostracous Crustacea (Fig. 496), that it would be impossible to show any decided difference between them. This is a very interesting example of the importance of becoming acquainted with the whole Natural History of an animal, whose place in the scale is at all doubtful.

ORDER XII.—ARANEIFORMES.

816. This is a very remarkable group, which is only referred to the position here assigned it, because it can scarcely be placed in any other,—at least without a more exact knowledge of its internal structure and development. It consists of the small family PYCNOGONIDA; which, in regard to the general form of the body, and the completeness of the extremities, seems to take rank rather with the higher Crustacea, or with the Arachnida. With the latter they have been commonly associated, on account of the number of their legs; but they differ in the absence of breathing pores, by which the want of internal respiratory organs may be inferred; and in their marine residence. There is reason to believe that the digestive cavity is not confined to the narrow body; but that it sends prolongations into the legs,—as it does into the rays of the Star-fish; and from this circumstance, as well as from the absence of a respiratory apparatus, the circulating system may be regarded either as incomplete, or as altogether wanting,—the respiration being provided for, as in the lower tribes of Crustacea, by the exposure of the fluids of the body to the surrounding medium. Further, the residence of these animals would seem to remove them from the Arachnida; for they are all marine, many being found amongst plants or stones on the sea-beach, and others being dredged up from deep water. Their minuteness renders it difficult to ascertain many points of their structure; and much is still to be learned respecting them. Various species exist on our own coasts. Their motions are remarkably slow and apparently difficult; and it is obvious from this circumstance,

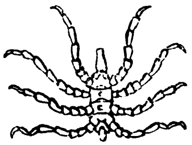

FIG. 503.—PYCNOGONUM BALÆNARUM.

as well as from the conformation of the mouth, that their prey must consist of either dead animal matter, or of living animals as defenceless as themselves. The females are distinguished by the possession of a pair of spurious legs (Fig. 504), placed in front of the rest, and appropriated to the purpose of holding and carrying the eggs. These are collected into globular masses, enveloped with a thin skin or membrane, each mass being firmly adherent to the limb. There are several of these masses in most species of the tribe; but in *Pycnogonum* itself, the eggs form a single broad square membrane laid under the body.—The proboscis of these curious animals, which seems to refer them to the group of Suctorial Crustacea, is really the entire head; and the organs which have been usually described under the name of palpi and mandibles, as appertaining to it, are in reality appendages of the thorax, and must be considered as metamorphosed legs; so that the Pycnogonidæ really have seven pairs of legs, like the Crustacea to which they are most nearly allied.

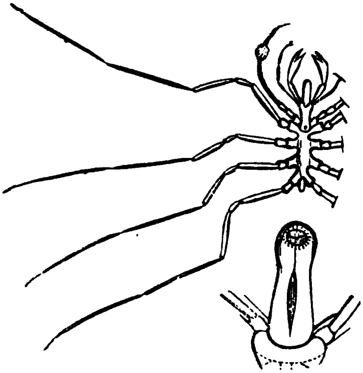

FIG. 504.—NYMPHON GROSSIPES, and under side of its Beak.

There now only remains to be considered the third sub-class of the Crustacea; which consists of but a single Order.

ORDER XII.—XYPHOSURA.

817. Although this group only contains a single genus, the *Limulus*, or King-crab, yet the structure of this departs so widely from that of all the Crustacea we have hitherto considered, that it cannot be referred to the same Order, or even

the same Sub-Class, with any of them. The Limuli,—which are Crustacea of considerable size, sometimes attaining the length of two feet,—have their bodies divided into two parts; of which the anterior, covered by a large semicircular shield (*e*, Fig. 506), bears the eyes, the antennæ, and six pairs of legs, which surround the mouth (*b*), and are used both for walking and for mastication; whilst the posterior portion of the body, which is covered by another shield of a somewhat triangular shape, bears on its under surface five pairs of swimming legs, of which the last is furnished with gills; and this triangular shield terminates in a long pointed process (*q*). Now when we compare the appendages to the head and body of these animals, with those of ordinary Crustacea, it is evident that the first pair of the legs surrounding the mouth of the Limulus represents their mandibles; that the second and third pairs represent their maxillæ; the three following pairs of legs their feet-jaws; and the five pairs of swimming-members, abdominal fin-feet,—the true thoracic legs being altogether absent. Besides the pair of compound eyes, characteristic of the Crustacea in general, the Limuli have a pair of small simple eyes, placed anteriorly, near

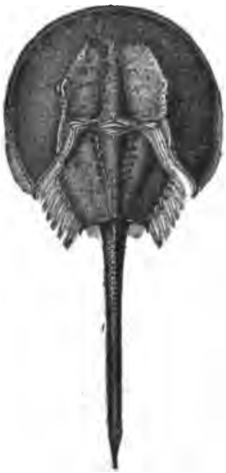

FIG. 505.—LIMULUS.

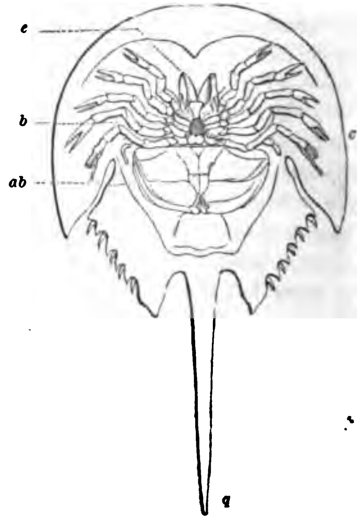

FIG. 506.—UNDER SURFACE OF LIMULUS.

the central line.—The Limuli are confined to the shores of tropical Asia, the Asiatic Archipelago, and tropical America. As the best-known species comes from the Mollucca Islands, they are sometimes termed Molucca Crabs. Of their habits very little has been ascertained. They appear to prefer the neighbourhood of sandy shores, and it is said that when kept from the water, they bury themselves in the sand, in order to avoid the violent heat of the sun, which causes them speedily to perish. They feed upon animal flesh. The long horny process of the posterior shield is not developed in the young animal; which also wants the posterior or branchial members. This process is used by some of the Malays as a point for their arrows; the wounds it makes being dangerous, like those made by the spines of many Fishes, on account of their jagged character. On the coast of America, where the Limulus is known as the Casserole Fish, the shell is employed as a ladle for water.—Fossil remains of this genus are not uncommon in the Secondary and Tertiary strata; and it may be further remarked that, in several particulars, the *Trilobites* may be regarded as having been probably analogous to it.

Geographical Distribution of Crustacea.

The extensive study of this large and important class, by M. Milne-Edwards, has enabled him to arrive at some very interesting conclusions in regard to its Geographical Distribution. An outline of these will be here introduced, because they would probably serve, with some modifications, to represent the general facts relating to the distribution of other Classes.

818. It has been pointed out, in the preceding sketch of the principal forms of the Crustacea, that different species have different localities, or residences assigned to them (as it were), on the surface of the globe. We have seen that some are exclusively confined to fresh water,—that others are inhabitants of the brackish water of estuaries,—that others take up their abode on the shore, where they are periodically covered and left dry by the tide,—that others frequent the shallow waters in the neighbourhood of the shore,—that others are found near the bottom of the deeper waters, at no great distance from land,—that others,

again, roam freely through the open sea,—and finally, that others are only to be met with on the dry land, at a considerable distance from the shore. Thus we see that each species has an appropriate *kind* of residence, for which it is peculiarly adapted by its organisation and habits; but it may be further stated, that each species has an appropriate *place* of residence, which is very much determined by the temperature of the region. It is true that there are many species very extensively distributed; but this results from their being adapted, by some peculiarities of structure and habit, which we cannot detect, to sustain life under a considerable variety of external conditions (§ 13). The extent to which even these species are distributed, however, will depend, in great part, upon the locomotive powers with which they are endowed, either in their adult or their young states; and also (in regard, at least, to all but the freely-swimming marine species) to the continuity of *a line of coast*, from one point to any other, along which their migrations may be effected. The existence of constant or periodical currents, too,—such as the Gulf Stream of Mexico,—will often affect the distribution of species; thus it is probably to this cause, that we are to attribute the presence of some American Crustacea on the shores of the Canary Islands.

819. The following are the general principles arrived at by M. Milne-Edwards in regard to the influence of *Temperature* on the Geographical Distribution of Crustacea.

I. *The different forms and modes of organisation of these animals manifest themselves more, in proportion as we pass from the Polar Seas towards the Equator.*—Thus, on the coasts of Norway, where there is frequently a vast multiplication of *individuals* of the same species, the number of *species* is very small; but the latter increase rapidly as we go southwards. Thus the number of species of Crustacea of the first two Orders, known to exist on the coast of Norway and the neighbouring seas, is only sixteen; but eighty-two are known to be inhabitants of the western shores of Britain, France, Spain, and Portugal; one hundred and fourteen are known in the Mediterranean Sea; and two hundred and two in the Indian Ocean. A similar increase may be observed in following the coast of the New World, from Greenland to the

Caribbean Sea; the number of species of Decapods in the former region being only twelve, whilst in the latter it is seventy-one.

II. *The differences of form and organisation are not only more numerous and more characteristic in the warm than in the cold regions of the globe; they are also more important.*—The number of natural groups, which we find represented in the Polar and Temperate Regions, is much smaller than that of which we find types or examples in Tropical Seas. In fact, nearly all the principal forms, which are met with in colder regions, also present themselves in warm; but a very large proportion of the latter have no representatives among the former. Thus, of the three primary groups, into which the Class is at first subdivided, the Xyphosura are altogether wanting beyond the forty-fourth degree of latitude. Again, the Brachyourous and Anamourous Decapods appear to be altogether excluded from some of the most northern regions that have been explored. Of the family of Squillidæ (§ 791), so highly characteristic of the Order Stomapoda, it is rare to meet with any members, north of the forty-fifth degree of latitude. And the curious group of Phyllopoda is restricted within a still nearer neighbourhood of the Tropical Region.

III. *Not only are those Crustacea, which are most elevated in the scale, deficient in the Polar Regions; but their relative number increases rapidly as we pass from the Pole towards the Equator.* Thus the Brachyoura, which must be considered as the most elevated of the whole series, are totally absent, as we have just seen, in some parts of the arctic region; and we find their place taken by the far less complete Edriophthalma, with a small number of Anomourous and Macrourous Decapods. In the Mediterranean, however, the Decapods surpass the Edriophthalma in regard to the number of species; and the Brachyourous division predominates over the Macrourous, in the proportion of two to one. And in the East and West Indies, the short-tailed are to the long-tailed Decapods, as three, four, or even five, to one.—Again, the *Land-Crabs*, which are probably to be regarded as taking the highest rank among the Brachyoura, are only to be met with between the tropics. And of the *fluviatile* Decapods (those which inhabit rivers, brooks, and lakes), a large proportion belong in tropical regions to the elevated type of the Brachyoura; whilst all those found in the temperate and arctic zones belong to the Macrourous division.

IV. When we compare together the Crustacea of different parts of the world, we observe that *the average size of these animals is considerably greater in tropical regions, than in the temperate or frigid climes.* The largest species of the arctic and antarctic seas, are far smaller than those of the tropical ocean; and they bear a much smaller proportion to the whole number. Further, in almost every group, we find that the largest species belong to the equatorial regions; and that those which *represent* them (or take their place, as it were) in temperate regions, are of smaller dimensions.

V. It is where the species are most numerous and varied, and where they attain the greatest size,—in other words, *where the temperature is most elevated,—that the peculiarities of structure, which characterize the several groups, are most strongly manifested.* Thus the transverse development of the cephalo-thorax, which is so remarkable in the Brachyourous Decapods (the *breadth* of the carapace of the typical Crabs being much greater than its length from back to front), is carried to its greatest extent in certain Crustacea of the Equatorial region; and the same might be stated of the characteristic peculiarities of most other natural groups. Further, it is in this region that we find the greater part of those anomalous forms, which depart most widely from the general structure of the Class.

VI. Lastly, *there is a remarkable coincidence between the temperature of different regions, and the prevalence of certain forms of Crustaceous animals.* Thus there are few *genera* to be met with in the West Indian seas, which are not represented in the East Indian,—the *species*, however, being usually different. The same may be said of the genera inhabiting the temperate regions of the globe;—similar generic forms being usually met with in the corresponding parts of the Old and New World, and of the Northern and Southern Hemispheres, although the *species* are almost invariably different.

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